United States
Department of
Agriculture

Economic
Research
Service

Agricultural
Economic Report
Number 479

U.S. Corn Industry

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U.S. CORN INDUSTRY, by Mack N. Leath, Lynn H. Meyer, and Lowell D. Hill. National Economics Division, Economic Research Service, U.S. Department of Agriculture. Agricultural Economic Report No. 479.

ABSTRACT

U.S. corn production nearly tripled between 1950 and 1979 in response to increased world demand. Corn is the largest grain crop in the United States, and U.S. corn accounts for 80 percent of global corn trade. U.S. farmers grew a record 7.9 billion bushels in 1979, spurred mostly by stepped-up average yields of nearly 110 bushels per acre. Growers will likely continue production at full capacity, prompted by increasing fuel alcohol and sweetener needs and an expanding world demand for grain.

Keywords: Corn, corn industry, grain marketing system, subsector analysis, grain distribution, exports.

NOTES

This publication is one of a series of reports prepared by the Economic Research Service to describe a subsector of the production and distribution system for food and feed grains in the United States. The following reports have been published:

U.S. Sorghum Industry, AER-457, June 1980
U.S. Rice Industry, AER-433, August 1979
U.S. Wheat Industry, AER-432, August 1979
U.S. Barley Industry, AER-395, February 1978

Copies are available from: EMS Publications, Room 0054-S, U.S. Department of Agriculture, Washington, D.C. 20250. This report was prepared in cooperation with the University of Illinois, Agricultural Experiment Station, Urbana.

Washington, D.C. 20250 February 1982

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HIGHLIGHTS

U.S. corn production annually accounts for over half of total world corn production, and the United States accounts for about 80 percent of annual world corn exports. Generally rising incomes have enabled people to include more meat in their diets. Thus, corn has become the foundation of a worldwide meat/feed grain boom that is expected to continue growing in the eighties.

U.S. grain production expanded rapidly during the seventies as corn became the Nation's largest crop. Corn represented 56 percent of total U.S. grain output, reaching a record 7.9 billion bushels in 1979, up 26 percent from the 1976 crop. Though acreage harvested increased by only 1 percent during that period, average yield soared, culminating in nearly 110 bushels per acre in 1979. However, the drought-plagued 1980 corn crop showed a per acre yield of only 91 bushels.

The drive to increase corn production in the United States was in response to a rapidly expanding world demand for feed grains. World consumption of corn increased more than 50 percent during the seventies, and world exports, led by American corn, rose 150 percent during that decade. The emergence of an alcohol fuel industry, deregulation of rail rates, and unstable export demand will likely pose both opportunities and problems for the U.S. corn industry in the eighties.

The recent increases in production and use (domestic and export) placed substantial demands on U.S. grain marketing and transportation systems. In 1977, more than 2.6 billion bushels of corn moved in interstate commerce, and 49 percent of that total moved by railroad. Trucks transported 16 percent of the total, and 35 percent moved by barge on the inland waterways. Nearly 97 percent of the corn moving on interstate waterways docked at ports for export.

About 80 percent of U.S. corn is grown in the highly concentrated production area encompassing the Corn Belt, Lake States, and the Northern Plains. About two-thirds of the quantity used for animal feed in the United States is fed on farms where produced. However, substantial volumes are shipped from the Corn Belt to livestock and poultry feeding areas in the Southeast, Delta States, and Pacific Region.

Producers and marketing firms dealt with highly variable prices and rapidly escalating costs during the seventies. Variations in yields triggered large fluctuations in production. The surplus stocks that accumulated in the late seventies led to the creation of the farmer-owned reserve programs for corn and other grains.

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INTRODUCTION

The United States annually produces about half the world's corn, and the U.S. acreage planted to corn has accounted for about 30 percent of the acreage planted to principal crops in recent years. On the average, about 10 million acres are harvested for silage and forage and the balance is harvested for grain. The acreage harvested for grain since 1950 has ranged from a low of 54.6 million acres in 1969 to a high of 73.1 million acres in 1980. The lower acreages in the sixties were associated with acreage control programs which were relaxed during the seventies. In the last 5 years, the acreage harvested for grain has averaged over 72 million acres.

Corn is harvested for grain in 41 of the 50 States; however, production is concentrated in the Corn Belt, most of which extends from eastern Ohio to the western sections of Iowa and Missouri and consistently accounts for more than 80 percent of the corn produced in the United States. The most important producing States are Illinois and Iowa, which generally grow about 40 percent of total production.

The acreage of corn harvested for grain increased during the seventies in response to expanding demands, and much of the increased production over time has come through higher yields. Average yields climbed from 37 bushels per acre in 1951 to 53 bushels per acre in 1959. Yields rose rapidly during the sixties, and by 1969, the average yield had jumped to 84 bushels per acre. Average yields were variable in the seventies due to corn blight and weather conditions, and ranged from a low of 72 bushels per acre in 1974 to a record high of 110 bushels per acre in 1979. These dramatic yield increases resulted primarily from the development of new high yielding hybrids, improved cultural practices, and high levels of fertilizer application.

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In the United States, corn is used for food, alcoholic beverage production, seed, and livestock feed. Total domestic use reached a record 5.2 billion bushels in 1979/80, and livestock feed accounted for about 88 percent of that total. Livestock feed use is very sensitive to grain prices, and in 1974/75, livestock and poultry producers reduced feed use by almost 25 percent, partly in response to record high corn prices. Use for food and industrial purposes expanded throughout the seventies due to increasing demand; the products exhibiting the greatest growth potential were corn sweetener products and alcohol fuel (gasohol).

The most dramatic change since 1950 has been the volume of corn exported. Exports grew from about 100 million bushels in 1950/51 to over 2.4 million bushels in 1979/80. The export volume increased over 370 percent during the seventies, and the trend is expected to continue in the eighties. The higher export levels placed new demands on the corn marketing and transportation systems and altered many traditional flow patterns.

There are several kinds of corn grown in the United States. Sweet corn and popcorn are specialty crops grown primarily for food use. A limited acreage of waxy corn is grown under contract with wet-corn millers. Waxy corn has a special chemical structure desired by some millers. Most of the field corn harvested for grain is dent corn. Its name is derived from the indentation in the crown of the kernel caused by shrinkage of the starch as the corn kernel dries. This report focuses on dent or field corn, and the term corn will be used hereafter to refer to this type of corn.

This report reviews changes that have occurred in the corn economy since 1950. This includes a review of supply, demand, and price relationships for corn, as well as costs of production and marketing, industry organization and practices, market flows, Government programs, and world production and trade.

SUPPLY

The United States is the world's leader in corn production; annual production generally exceeds 50 percent of the world total. The annual U.S. supply available for domestic use and exports consists primarily of production and stocks (table 1). Imports have been small and do not significantly affect annual supply. Carryover stocks are inventories of corn remaining in storage on October 1, the start of the new crop year. This date traditionally signifies the start of harvest and is the transition point from old-crop to new-crop corn.

Table 1--Corn supply, by position

Year beginning Oct. 1	Carryover--Oct. 1				Production	Imports	Total supply
	Farm	Interior mill, elevator, and warehouse	CCC bin-sites	Total			
	Million bushels						
1950/51	470	121	253	844	2,764	1	3,609
1951/52	313	112	315	740	2,629	1	3,370
1952/53	172	70	245	487	2,981	1	3,469
1953/54	330	55	384	769	2,882	1	3,652
1954/55	359	93	468	920	2,708	1	3,629
1955/56	314	161	560	1,035	2,873	1	3,909
1956/57	299	266	600	1,165	3,075	1	4,241
1957/58	419	427	573	1,419	3,045	2	4,466
1958/59	343	514	612	1,469	3,356	1	4,826
1959/60	325	634	565	1,524	3,825	1	5,350
1960/61	452	736	599	1,787	3,907	1	5,695
1961/62	588	813	615	2,016	3,598	1	5,615
1962/63	579	590	484	1,653	3,606	1	5,260
1963/64	534	435	396	1,365	4,019	1	5,385
1964/65	681	442	414	1,537	3,484	1	5,022
1965/66	581	258	308	1,147	4,084	1	5,232
1966/67	532	176	134	842	4,168	1	5,011
1967/68	572	156	98	826	4,860	1	5,687
1968/69	788	277	104	1,169	4,450	1	5,620
1969/70	732	243	143	1,118	4,687	1	5,806
1970/71	576	318	111	1,005	4,152	4	5,161
1971/72	427	215	25	667	5,646	1	6,314
1972/73	751	349	26	1,126	5,580	1	6,708
1973/74	405	284	20	709	5,671	1	6,380
1974/75	288	196	0	484	4,701	2	5,187
1975/76	192	169	0	361	5,841	2	6,204
1976/77	234	166	0	400	6,289	2	6,691
1977/78	448	438	0	886	6,505	3	7,394
1978/79	666	445	0	1,111	7,268	1	8,380
1979/80	795	509	0	1,304	7,939	1	9,244
1980/81 1/	921	696	0	1,617	6,648	1	8,266

1/ Estimated.

Sources: (39, 43).

Total supply increased dramatically during the seventies, reaching a record 9.2 billion bushels in 1979/80.

Carryover Stocks

The carryover of old-crop corn into the new marketing year represents a net addition to the supply available for use during the marketing year, October 1 to September 30. Carryover stocks are working inventories and excess supplies from the previous marketing year. Processors, exporters, and livestock feeders require pipeline stocks during the transition from one marketing year to the next.

The variation in carryover stocks during the study period (1950-80) largely reflects changes in inventories controlled by the Government (owned by the Commodity Credit Corporation (CCC), pledged as collateral in the CCC loan program, or stored in the producer-owned reserve program). Carryover stocks reached a record 2 billion bushels in 1961; CCC owned 66 percent of those inventories. At that time, a sizable proportion of those CCC-owned stocks (615 million bushels) was stored in CCC binsites. The binsite storage program was discontinued in the early seventies and the bins were sold. CCC-owned stocks are currently stored in commercial warehouses.

Carryover stocks in mills, elevators, and warehouses also reached a peak of 813 million bushels in 1961. Only 101 million bushels of that amount were privately owned, the balance being CCC-owned stocks. Privately owned stocks have trended upward over time along with the working inventory requirements of processors, livestock feeders, and exporters. Since 1977, privately owned carryover stocks stored off-farm have averaged 430 million bushels--apparently a normal pipeline stock at current levels of use. Carryover stocks reached a record low for recent years in 1975 following the drought-reduced crop of 1974.

Trends in Acreage, Yield, Production, and Farm Sales

Corn is grown in almost every State; however, the majority of production is concentrated in the Corn Belt (fig. 1). 1/ The region has ideal climate, highly productive soil, and a relatively flat topography conducive to row cropping and the use of large efficient machinery. Since 1955, the Corn Belt has produced a relatively stable percentage of the total supply, but factors such as Government programs, changes in technology, and changes in soybean and sorghum acreages have caused shifts in production in other regions.

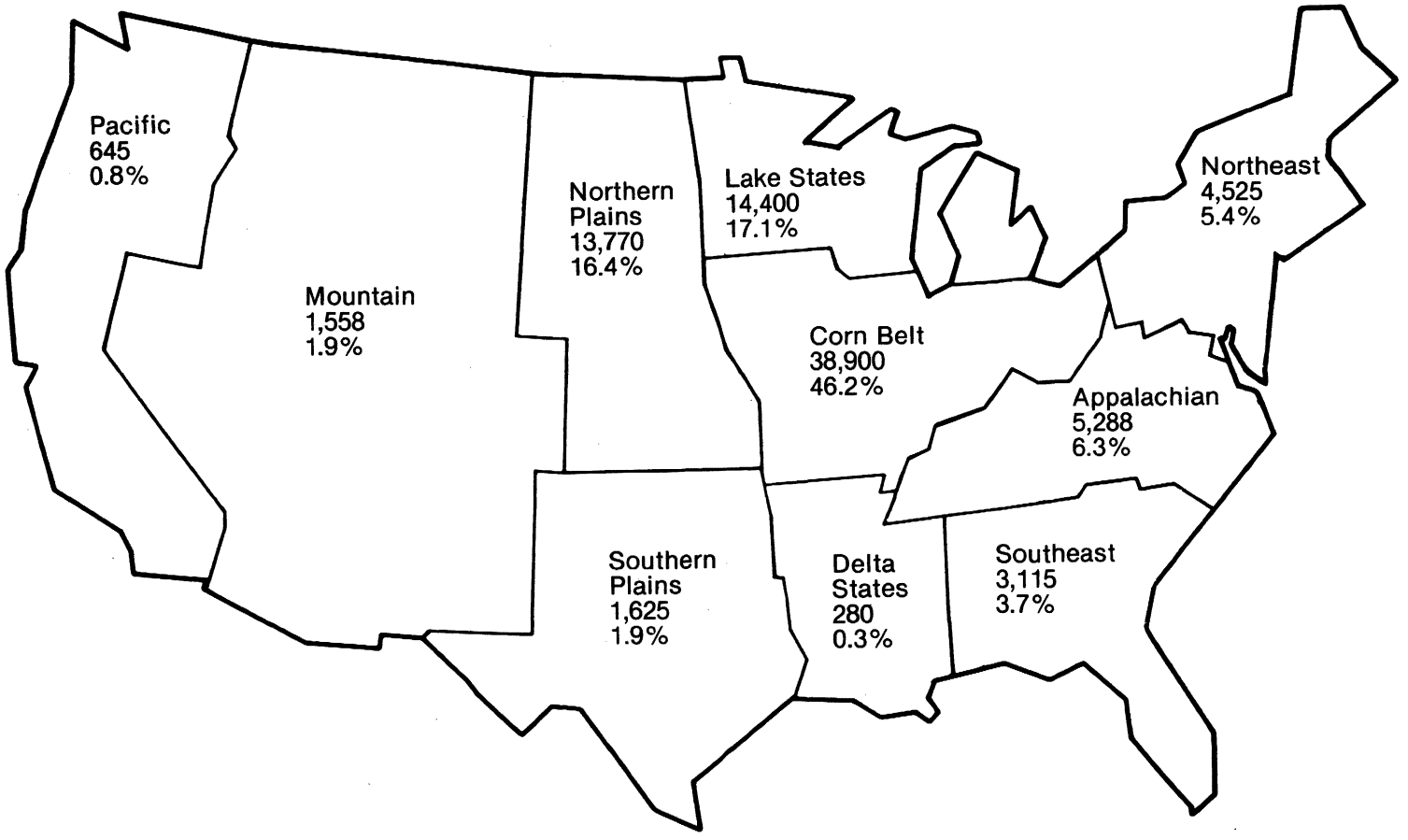
Acreage

The corn acreage planted for all purposes exhibited sizable variations during the study period. During the fifties,

1/ The Corn Belt, as used in this study, refers to Ohio, Indiana, Illinois, Iowa, and Missouri.

Figure 1

Acreage of Corn Planted for All Purposes in 1980 *



*The top number in each region refers to acreage planted (unit = 1,000 acres), and bottom number refers to percentage of total acreage.

acreage planted trended downward until 1959, when Government acreage controls were relaxed for 2 years. Acreage then increased by more than 9 million acres, up almost 13 percent (table 2). Acreage restrictions were resumed in 1961, and the corresponding drop in acreage planted was 15.5 million acres. During the sixties and early seventies, the acreage planted stabilized at about 67 million acres. However, between 1972 and 1976, acreage increased 26 percent and has exceeded 81 million acres during the past 5 years, or about the same as that of the early fifties, when acreage controls were not in effect.

Soybean prices affect corn acreage because on most land, both soybeans and corn can easily be substituted for each other depending on which will yield a higher expected profit. Restrictions on corn acreage and price support programs for both corn and soybeans were the major factors that determined yearly corn plantings before 1972. After 1972, acreage restrictions were removed in response to the dramatic increase in market prices, and corn acreage has since become largely a function of expected market prices for corn and soybeans. Planting decisions will be increasingly influenced by expected prices of corn and competing crops during the eighties, and Government feed grain programs will have a correspondingly smaller influence.

Yellow corn is the predominant type of corn grown in the United States. However, data have been collected on the acreage, yield, and production of white corn since 1971, and except for that year, harvested acreage has averaged about a half-million acres (table 3). White corn has become a specialty crop grown primarily for food uses, and annual production has not exceeded 40 million bushels since 1975.

Acreage harvested for silage has about doubled since 1950. Government programs restricting acreage have somewhat affected acreage harvested for silage (see 1961, 1968, and 1972 in table 2). However, prospective yields for grain and silage appear to be more important factors. Note, for example, that when drought conditions in the crop year 1974 reduced grain yields to 71.9 bushels per acre, the acreage harvested for silage jumped by 1.8 million acres (see table 2). As a result, silage production was maintained even though silage yields were off 2 tons per acre.

Table 2--Corn acreage, yield, and production

Crop year	Total acreage planted	Harvested for grain			Harvested for silage		
		Acreage	Yield per acre	Production	Acreage	Yield per acre	Production
	Million acres	Million acres	Bushels	Million bushels	Million acres	Tons	Million tons
1950	82.9	72.4	38.2	2,764	4.9	6.3	31.0
1951	83.3	71.2	36.9	2,629	4.8	8.1	39.0
1952	82.2	71.4	41.8	2,981	5.4	8.1	43.2
1953	81.6	70.7	40.7	2,882	6.1	7.8	47.9
1954	82.2	68.7	39.4	2,708	7.1	7.4	52.6
1955	80.9	68.5	42.0	2,873	7.0	7.6	53.0
1956	77.8	64.9	47.4	3,075	6.5	8.4	54.6
1957	73.2	63.1	48.3	3,045	6.1	8.8	54.1
1958	73.4	63.5	52.8	3,356	6.8	8.1	55.6
1959	82.7	72.1	53.1	3,825	7.0	8.5	59.7
1960	81.4	71.4	54.7	3,907	7.2	9.1	65.4
1961	65.9	57.6	62.4	3,598	6.3	10.6	66.1
1962	65.0	55.7	64.7	3,606	7.2	10.7	76.8
1963	68.8	59.2	67.9	4,019	7.7	10.8	82.9
1964	65.8	55.4	62.9	3,484	8.6	9.7	83.6
1965	65.2	55.4	74.1	4,103	8.1	10.5	84.4
1966	66.3	57.0	73.1	4,166	7.9	11.3	89.7
1967	71.2	60.7	80.1	4,860	8.4	11.3	94.8
1968	65.1	56.0	79.5	4,450	7.9	11.9	93.7
1969	64.3	54.6	85.9	4,687	7.9	12.6	99.2
1970	66.8	57.4	72.4	4,152	8.1	11.6	93.8
1971	74.1	64.1	88.1	5,646	8.8	12.4	109.3
1972	67.0	57.5	97.0	5,580	8.3	13.1	109.3
1973	71.9	62.1	91.3	5,671	9.0	12.7	114.3
1974	77.9	65.4	71.9	4,701	10.8	10.7	115.7
1975	78.7	67.6	86.4	5,841	9.8	11.8	116.1
1976	84.6	71.5	88.0	6,289	11.3	10.5	118.5
1977	84.3	71.6	90.8	6,505	9.3	12.6	117.7
1978	81.7	71.9	101.0	7,268	8.6	13.7	118.1
1979	81.4	72.4	109.7	7,939	8.0	14.4	114.9
1980 1/	84.1	73.1	91.0	6,648	9.3	12.0	111.1

1/ Preliminary.

Sources: (39, 42, 48).

Yields

During the study period, corn yields increased 186 percent, culminating with a 110-bushel per acre average in 1979. The average yield for selected 5-year periods are presented below:

5-year period	Average yield per acre	Percentage increase
	Bushels	Percent
1950-54	39.4	N.A.
1955-59	48.7	23.6
1960-64	62.5	28.3
1965-69	78.5	25.6
1970-74	84.1	7.1
1975-79	95.2	13.2

N.A. = not applicable.

Yields increased less dramatically during the midseventies and were more variable. Southern corn blight, for example, reduced yields significantly in 1970. The acreage expansion during the midseventies curbed the trend toward higher yields because

Table 3--White corn acreage, yield, and production1/

Crop year	Acreage harvested	Yield per acre	Production
	1,000 acres	Bushels	1,000 bushels
1971	1,067	76.8	81,937
1972	429	82.7	35,475
1973	509	81.5	41,465
1974	611	64.3	39,295
1975	616	68.3	42,076
1976	498	77.8	38,739
1977	441	69.4	30,591
1978	497	76.3	37,935
1979	366	89.4	32,709
1980 2/	443	65.3	28,934

1/ Included in corn for grain data in table 2.
2/ Preliminary.
Source: (42)

marginal, less productive land had been placed in corn production. The average yields in 1978 and 1979 rose sharply, following the trend established in the early fifties. However, the 91-bushel average in 1980 abruptly ended steady yield increases.

The general increase in yields over time is due mainly to changes in technology and production practices, including development of improved high yielding hybrids, increased rates of fertilization, higher seeding rates, and improved control methods for weeds, insects, and diseases. The greater variability in yields, which occurred during the seventies, evolved primarily from the weather. Just as drought conditions reduced yields significantly during 1974 and 1980, extremely favorable weather conditions in 1978 and 1979 produced record yields. The record yield of 110 bushels per acre in 1979 seemed unreachable just a few years earlier.

Average yield per harvested acre for silage has increased more slowly than grain yields. Yields in the seventies averaged about 50 percent above yields in the fifties, and average yield for the 1979 crop was a record 14.4 tons per acre. Drought conditions in 1980 reduced average silage yields by 17 percent.

Yield is a major factor that favors yellow corn over white corn as a production alternative. Since 1971, all corn harvested for grain averaged about 91 bushels per harvested acre (see table 2). White corn has averaged only 75 bushels per harvested acre (see table 3).

Production

While acreage has varied significantly from year to year, total production of corn has generally trended upward, more than doubling since 1950, from 2.8 billion bushels to the record crop of 7.9 billion bushels in 1979 (see table 2). The obvious explanation is that increasing yields have more than offset declines in acreage during the sixties when Government acreage controls were in effect. The acreage harvested for grain in recent years is about the same as in 1960, however, production has almost doubled since 1960.

Production of silage has increased steadily since 1950, and averaged 116 million tons during 1975-79. In general, producers have offset yield variations by changing harvested acreage so that production levels meet livestock feeding needs.

Farm Sales

Changes in the quantity of grain sold from farms generally reflects changes in production (table 4). The quantity used on producing farms was fairly stable during the fifties and sixties and varied from 1.7 to 2.3 billion bushels. Use on farms dropped to the lowest level since 1955 during the drought year

Table 4--Corn production for grain and farm disposition

Crop year	Production for grain	Disposition on farms where produced		
		Feed and seed	Home use	Sold
		Million bushels		
1950	2,764	1,963	12	789
1951	2,629	1,872	10	747
1952	2,981	1,898	9	1,075
1953	2,882	1,799	7	1,075
1954	2,708	1,652	6	1,050
1955	2,873	1,720	5	1,147
1956	3,075	1,818	5	1,252
1957	3,045	1,850	4	1,190
1958	3,356	2,003	3	1,350
1959	3,825	2,144	3	1,677
1960	3,907	2,127	2	1,777
1961	3,598	2,115	N.A.	1,482
1962	3,606	2,043	N.A.	1,562
1963	4,019	2,144	N.A.	1,875
1964	3,484	1,781	N.A.	1,703
1965	4,103	2,089	N.A.	2,014
1966	4,168	2,062	N.A.	2,105
1967	4,860	2,263	N.A.	2,598
1968	4,450	2,095	N.A.	2,355
1969	4,687	2,130	N.A.	2,557
1970	4,152	1,888	N.A.	2,264
1971	5,646	2,449	N.A.	3,197
1972	5,680	2,432	N.A.	3,248
1973	5,671	2,231	N.A.	3,440
1974	4,701	1,777	N.A.	2,924
1975	5,841	2,117	N.A.	3,724
1976	6,289	2,305	N.A.	3,984
1977	6,505	2,514	N.A.	3,991
1978	7,268	2,783	N.A.	4,485
1979	7,939	2,976	N.A.	4,963
1980 1/	6,648	2,502	N.A.	4,146

N.A. = not available.
1/ Preliminary.

Sources: (39, 47).

of 1974. Onfarm use rebounded since that time and approached 3 billion bushels in 1979/80. Meantime, the quantity sold increased over 500 percent during the study period, and sales approached the 5-billion-bushel mark in 1979/80.

Production Location

The Corn Belt is the primary corn producing area, accounting for over 55 percent of the total U.S. production (table 5). The Corn Belt region increased its regional share of production by 6.6 percent and its regional share of harvested acres by 9.1 percent between 1950 and 1960. Both the regional share of production and the regional share of harvested acres for the Corn Belt increased slightly from 1960 to 1970 and then showed a small decrease in 1979.

Although the Corn Belt has led all regions in corn production, the Lake States region has shown the greatest increase in acreage and production. Both its regional share of harvested acres and share of production almost doubled since 1950. That region surpassed the Northern Plains during the seventies and currently ranks second among all regions in corn production. During the same period, opposite trends developed in the Southeast and Delta States. Between 1950 and 1960, these regions had decreases of 3.6 percent in their regional shares of production and 6.4 percent in their regional shares of harvested acres. These downward trends continued during the sixties and seventies. These trends were primarily the result of a decrease in corn acreage in the South, caused by increased substitution of more profitable crops such as soybeans.

Although the shift of acreage out of the Southeast and Delta States was the major trend during the study period, there was another small but significant regional change. The Mountain and Pacific regions increased their regional share of production by 2 percent. The Northeast had a 1.5-percent increase in percentages of harvested acres and its regional share of production was maintained.

Iowa continued to be the leading corn producing State through 1979, accounting for 18 percent of the acreage harvested for grain and 21 percent of the production. Illinois ran a close second with 15 percent of the acreage and almost 18 percent of the production. Nebraska, Indiana, and Minnesota followed, combining for about 27 percent of the Nation's corn acreage and production. Ten States produced over 200 million bushels in 1979 and accounted for more than 80 percent of total U.S. production:

State	Acreage harvested		Production	
	1,000 acres	Percentage of total	Million bushels	Percentage of total
Iowa	13,100	18.1	1,664	21.0
Illinois	11,050	15.3	1,414	17.8
Nebraska	7,150	9.9	822	10.4
Indiana	6,030	8.3	675	8.5
Minnesota	6,060	8.4	606	7.6
Ohio	3,630	5.0	417	5.3
Wisconsin	3,080	4.3	317	4.0
Missouri	2,330	3.2	240	3.0
Michigan	2,500	3.5	238	3.0
South Dakota	2,850	3.9	211	2.7
10 States	57,780	79.9	6,604	83.3

Production Practices

Many changes in the technological and financial aspects of corn production resulted in a rapid increase in productivity per hour of labor since 1950. Some of the contributing factors were:

- An increase in the average farm size.
- Larger, more efficient machinery.
- An increase in onfarm storage capacity.
- More sophisticated managerial techniques.
- Government price supports.
- Increased fertilizer application rates.

Trends and Description of Cultural Practices

Intensive use of a moldboard plow, disk, harrow, and cultivator was once the only practical tillage system for seedbed preparation and weed control. The adoption of modern herbicides during the study period made possible alternatives to the traditional intensive tillage system. Farmers are increasingly substituting the chisel plow for the moldboard plow as the primary tillage implement. The chisel plow leaves the soil surface rough and partially covered by crop residues which reduce water and wind erosion, very important considerations when primary tillage is done in the fall after harvest.

Table 5--Shifts in corn acreage, yield, and production

Region	Crop year				
	1950	1960	1970	1979	1980
	Percent				
Regional share of harvested acres:					
Northeast	2.5	2.5	3.5	3.8	4.0
Lake States	8.9	12.9	13.6	16.1	16.7
Corn Belt	39.4	48.5	53.7	49.9	50.6
Northern Plains	17.5	16.8	15.1	16.3	15.0
Appalachian	10.2	7.5	6.0	5.9	6.2
Southeast	9.5	6.6	5.0	4.0	3.5
Delta States	5.9	2.4	.7	.3	.2
Southern Plains	5.3	2.0	1.1	1.8	1.9
Mountain	.7	.5	.9	1.4	1.4
Pacific	.1	.3	.4	.5	.5
Regional yield relative to national average:					
Northeast	120.2	113.5	118.1	87.0	86.4
Lake States	107.1	101.9	115.4	90.9	108.2
Corn Belt	128.9	118.4	107.1	111.3	109.3
Northern Plains	87.8	82.6	88.4	95.1	86.4
Appalachian	93.9	84.2	71.7	78.8	66.9
Southeast	49.3	53.3	39.9	59.8	47.2
Delta States	60.6	49.3	46.7	48.9	34.6
Southern Plains	55.0	43.3	87.9	96.0	97.7
Mountain	63.2	91.7	124.7	110.3	122.9
Pacific	107.5	136.0	135.9	107.8	143.3
Regional share of production:					
Northeast	3.1	2.9	4.1	3.3	3.5
Lake States	9.5	13.2	15.7	14.6	18.1
Corn Belt	50.8	57.4	57.6	55.6	55.4
Northern Plains	15.3	13.8	13.4	15.5	12.9
Appalachian	9.6	6.3	4.3	4.7	4.1
Southeast	4.7	3.5	2.0	2.4	1.7
Delta States	3.6	1.2	.3	.1	.1
Southern Plains	2.9	.9	.9	1.8	1.8
Mountain	.4	.4	1.1	1.5	1.7
Pacific	.1	.4	.6	1.8	.7

Sources: (39, 42).

Current relatively high yields depend upon plant nutrients supplied by commercial fertilizers. Harvested grain and silage remove more nitrogen than any other nutrient from the soil. Nitrogen is also lost through erosion, denitrification, and leaching. The rate of application varies by soil type. Yield potential is one of the major considerations in determining the optimum rate of nitrogen application.

Most corn is planted between late April and early May. Corn can be planted as early as the beginning of March in the southern part of the Nation. The ideal planting depth is about 2 inches, and the rate of planting is between 20,000 and 26,000 kernels per acre.

Irrigation is not a common practice in the Corn Belt; however, it is used extensively in drier sections of the country. Because of irrigation, yields in these nontraditional corn producing areas are comparable to typical yields in the Corn Belt.

The benefits of irrigation in these nontraditional areas can be illustrated by comparing yields for irrigated and nonirrigated acreages in three major States that rely heavily on irrigation in the production of corn. The proportion of acreage irrigated and estimated yields in selected States for 1979 are as follows:

State	Area harvested	Irrigated corn		Nonirrigated corn	
	1,000 acres	Percent	Bushels/acre	Percent	Bushels/acre
Nebraska	7,150	69	128	31	86
Kansas	1,470	69	127	31	90
Texas	1,260	78	118	22	60
Three States	9,880	70	126	30	87

Corn yields on irrigated land were 45 percent greater than nonirrigated acreage yields in these States. Although less important in terms of acreage harvested, almost 90 percent of the corn grown in California and Colorado in 1979 was irrigated. Without irrigation, corn production in the Plains and Western States would be curtailed significantly, and the land currently devoted to corn production would shift to other crops that are adaptable to drier climates. Over 70 percent of the irrigated corn acreage in Texas is in the Panhandle where the water table

is falling because of extensive irrigation. Consequently, corn acreage is expected to decline there as pumping irrigation water becomes more expensive and the water's availability becomes more limited.

Varieties and Types

In 1950, 78 percent of the U.S. corn acreage and 99 percent of the acreage in the Corn Belt were planted with hybrid seed (39, 1952, p. 40). 2/ Farmers continued switching from open-pollinated varieties to hybrids in the early fifties. The hybrids were inherently more productive, and perhaps more responsive to favorable cropping practices than traditional varieties. Research has continued to develop new hybrids more responsive to high levels of fertilization, high plant populations, and other improved cropping practices. Much of the plant breeding research has involved yellow corn, and as a result, over 99 percent of the corn harvested for grain in the United States is a yellow type.

Harvesting Methods

Some fairly dramatic changes have occurred in harvesting and handling methods since 1950. In 1956, field shelling of corn was introduced, and the proportion harvested as ear corn has declined steadily since that time. In Illinois, for example, about 2 percent was harvested as shelled corn in 1956. In 1965, the proportion field-shelled had increased to 53 percent, mostly harvested using a combine with corn head (fig. 2). The proportion of Illinois corn harvested by various methods in 1980 was as follows:

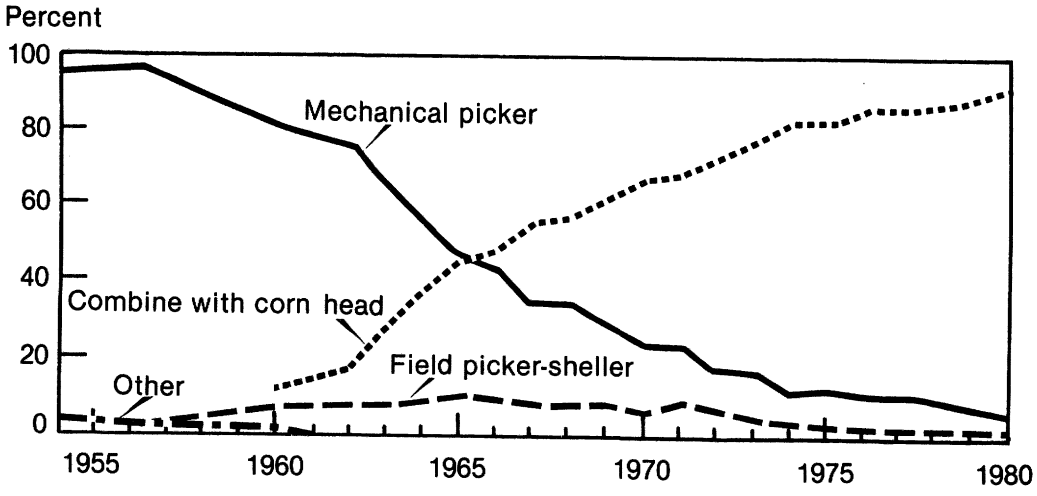
Method of harvest	Percent
Combine with corn head	91.5
Mechanical picker	6.5
Field picker-sheller	2.0

The higher machinery cost associated with field shelling and larger acreages has encouraged early harvesting. Corn Belt harvesting usually begins in September and ends during October. Early harvesting reduces field losses. However, since the corn usually has a moisture content that is too high for safe storage, it must be dried. Currently, about 80 percent of the quantity produced in major corn producing States is artificially dried on the farm.

2/ Underscored numbers in parentheses cite sources in the References section.

Figure 2

Methods Used for Harvesting Corn for Grain in Illinois 1/



1/ Straight line interpolation used for years for which data were not available.

Production Potential

Future U.S. corn production will depend upon changes in acreage and yield. From 1950 through the early seventies, Government programs had the greatest impact on acreage, restricting it through allotments and acreage diversions. The late seventies brought very limited Government involvement in acreage; consequently, corn acreage planted and harvested for grain rebounded to levels of the early fifties. The acreage of corn harvested for grain stabilized at about 72 million acres during the 1976-80 period. Without Government controls, this acreage is likely to be maintained during the eighties unless a substantial change develops in the relationship between corn and soybean prices. Corn and soybeans compete for acreage in the Corn Belt; producers respond to changes in the relative profitability of these crops.

The area planted to principal crops in 1980 totaled 357 million acres, up 10 million acres from 1979 and the largest since 1953 (42, p. A-9). Corn acreage was up 3 percent over 1979 and surpassed the 84-million-acre mark for only the third time since 1950. Soybean acreage declined from the record 1979 level of 71.6 million acres to 70.1 million acres in 1980, and most of those acres were probably shifted to corn production. The export demand for soybeans has not increased as rapidly as the export demand for corn in recent years. If this trend continues, additional acreage may be diverted from soybeans to

corn in the Corn Belt. The total acreage devoted to corn production during the eighties is not expected to differ greatly from current levels.

If corn acreage remains stable as expected, increases in production will be the result of increasing yields. From 1950 to 1979, the average annual increase in yield was 2.37 bushels per acre. Many different production practices contributed to this increase. These included higher plant population; higher yielding hybrids; higher fertilization rates; and improved insect, disease, and weed control. Yields do not appear to be leveling off as was predicted a few years ago. Yields should continue to rise as long as producers continue to adopt favorable production practices developed through research and to select hybrids with high yield potential.

Increases in yields will depend upon an adequate supply of irrigation water in several States in the Great Plains and West. A reduction in the amount of water available for irrigating corn in those States would likely reduce the number of acres irrigated and reduce average yield because irrigated acreage would become a smaller proportion of total acreage in those States.

The feasibility of increasing production and yield at the predicted rates depends upon continued growth in domestic use and export demand for corn. If demand fails to keep pace with the production potential from current acreage, some land would need to be diverted from corn production to an alternative crop such as soybeans.

DEMAND

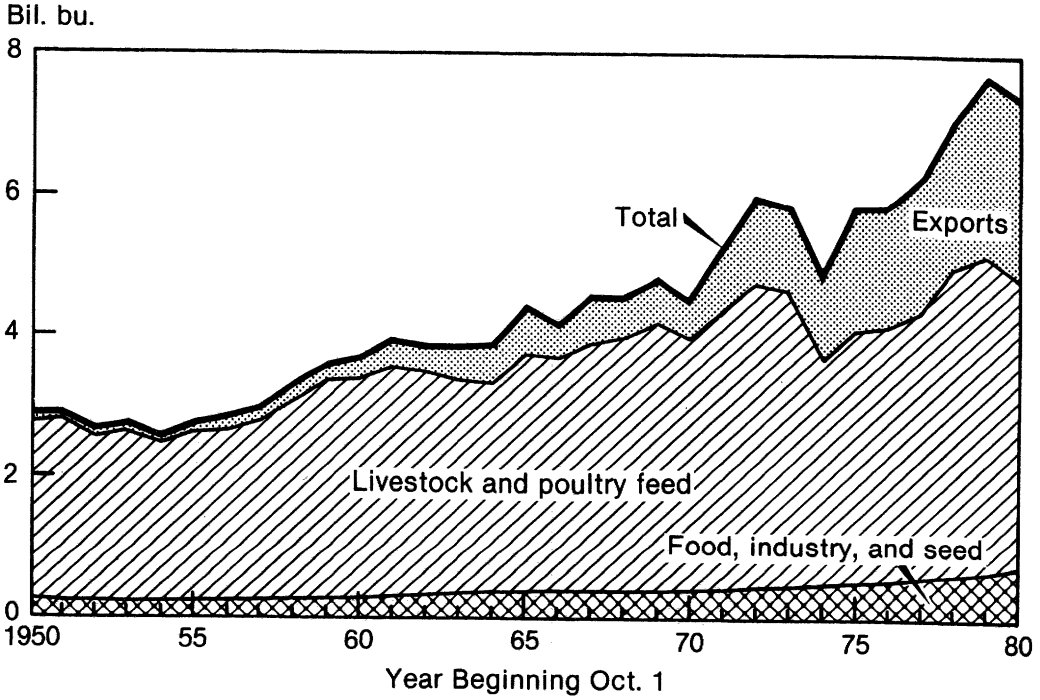
More corn is produced in the United States than any other feed grain. Domestic use currently accounts for about 60 percent of total annual disappearance, and the balance is exported. Livestock and poultry feed accounted for almost 84 percent of total domestic use in 1979/80. Although much smaller in terms of volume, industrial use (food, industry, and alcoholic beverages) grew steadily throughout the study period, reaching 600 million bushels in 1978/79. Seed is the other major domestic use and is small compared with feed and industrial uses. About 2.5 billion bushels of corn are exported each year, and the volume is expected to increase (fig. 3).

Domestic

Domestic utilization trended upward during the fifties and sixties and reached the 4-billion-bushel mark in the 1969/70 marketing year (table 6). Record prices due to tight supplies in 1974/75 resulted in a domestic use drop of almost 1 billion bushels, reflecting the tremendous adjustment made by the livestock industry in response to high grain prices. Domestic

Figure 3

Major Uses of Corn



use has increased since that time, surpassing the 5-billion-bushel mark in 1979/80.

Livestock and Poultry Feed

Corn accounts for about 80 percent of the total quantity of grain fed to livestock in the United States, and that proportion is expected to increase. Feed use has ranged from a low of 2.2 billion bushels in 1954/55 to a record high of 4.5 billion bushels in 1979/80 (table 6). The variation in feed use reflects the change in number of animals fed as well as ration adjustments made by livestock and poultry producers in response to relative prices and availability of corn and competing feed ingredients.

A sizable proportion of U.S. cattle and hogs are located on grain producing farms. Consequently, about 60 percent of the corn used as animal feed is fed on the farms where produced (see table 4). The balance is purchased from nonfarm sources as whole corn or prepared animal feeds. Prepared animal feed manufacturers use corn byproducts produced by dry-corn millers (hominy feeds), wet-corn processors (corn gluten meal and corn gluten feed), and distillers (distiller's dried grain).

Demand for corn by livestock and poultry producers is highly seasonal, generally peaking in the fall and winter. Feed use

Table 6--Corn disappearance, by use

Year beginning Oct. 1	Domestic use					Exports	Total disappearance
	Food and industry 1/	Alcoholic beverages	Seed	Feed 2/	Total		
	Million bushels						
1950/51	188	72	12	2,482	2,753	117	2,870
1951/52	178	56	12	2,555	2,801	82	2,882
1952/53	183	47	12	2,312	2,554	145	2,670
1953/54	176	53	13	2,388	2,629	104	2,732
1954/55	188	49	12	2,242	2,491	103	2,594
1955/56	192	54	12	2,366	2,624	120	2,744
1956/57	192	57	11	2,378	2,638	184	2,822
1957/58	195	57	11	2,534	2,797	200	2,997
1958/59	211	65	13	2,783	3,072	230	3,303
1959/60	215	62	12	3,043	3,333	230	3,563
1960/61	219	64	11	3,092	3,387	292	3,679
1961/62	235	69	11	3,213	3,528	435	3,963
1962/63	247	65	11	3,156	3,479	416	3,895
1963/64	264	65	11	3,009	3,348	500	3,849
1964/65	271	67	11	2,956	3,305	570	3,875
1965/66	277	71	13	3,362	3,722	687	4,409
1966/67	282	73	14	3,323	3,697	487	4,184
1967/68	291	74	13	3,524	3,886	633	4,519
1968/69	272	75	12	3,607	3,966	536	4,501
1969/70	278	74	13	3,825	4,190	612	4,801
1970/71	299	69	17	3,593	3,978	517	4,495
1971/72	324	70	15	3,982	4,391	796	5,187
1972/73	359	75	16	4,292	4,742	1,258	6,000
1973/74	374	80	18	4,181	4,653	1,243	5,896
1974/75	412	66	19	3,180	3,677	1,149	4,826
1975/76	432	71	20	3,570	4,093	1,711	5,804
1976/77	456	74	20	3,571	4,121	1,684	5,805
1977/78	500	70	20	3,744	4,334	1,948	6,282
1978/79	531	69	20	4,324	4,944	2,133	7,077
1979/80	583	72	20	4,518	5,193	2,433	7,626
1980/81 3/	657	73	20	4,127	4,877	2,355	7,232

1/ Includes corn processed for gasohol and corn sweetener products.
2/ Residual which approximates feed use.
3/ Estimated.

Sources: (39, 43).

is usually the lightest during the summer reflecting a greater use of wheat when prices are at a seasonal low. A series of analyses made by the Economic Research Service (ERS) during 1975 and 1976 determined the factors that affected the use of corn for livestock feed (2, 3, 4, 5). These analyses revealed that the most important determinants of the quantity of corn used for feed are: the price of corn; the price of soybean meal; the value of beef, pork, and broiler production; the quantity of wheat fed; and the price received by farmers for livestock and livestock products. Profitability of livestock and poultry production was also found to be important. (For additional information on analyses of corn demand, read 1, 8, 9, 25, 26, 34.)

The swine industry is the largest user of corn, and in 1979/80, hogs consumed an estimated 43.9 million metric tons, or 38 percent of total corn fed (table 7). Cattle on feed and other beef cattle accounted for about 24 percent of the quantity of corn consumed by animals. The poultry and dairy industries accounted for 20 percent and 16 percent of consumption, respectively. Use by the dairy industry has exhibited a fairly stable upward trend over time, reflecting a more stable price structure for dairy products compared with other livestock products and the fact that the industry does not adjust rapidly to shortrun changes in grain prices.

The relatively low feed use in 1974/75 reflected sizable adjustments in cattle and hog feeding. The hog and poultry industries expanded rapidly in the following years, and corn use by these industries returned to record levels by 1976/77. Adjustments in fed beef production came more slowly; corn use by this industry is still below the record levels of the early seventies.

Food and Industry

Domestic use of corn for food and industrial purposes has been relatively small compared with the annual volume used for livestock and poultry feed. Most of the corn moving into food and industrial uses is processed by either the wet-corn processing industry or the dry-corn milling industry. A large proportion of the primary products of these industries (meal, grits, flour, and starch) is further processed into breakfast foods, corn sweetener products, ethanol alcohol, pet foods, and many other products.

The fifties and sixties were periods of slow but rather steady growth in the quantity of corn used for food and industrial purposes. The annual growth rate averaged about 2.5 percent during these years. Food and industrial use doubled during the seventies, mostly because of expanding markets for sweetener products. In 1979/80, food and industrial use increased by

Table 7--Estimated consumption of corn, by kind of livestock

Kind of livestock	Year beginning Oct. 1							Average
	1974/75	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81 1/	
	Million metric tons							
Dairy animals	13.3	13.5	15.4	16.1	17.9	18.7	17.5	16.1
Cattle on feed	14.2	19.2	18.7	21.4	22.9	21.5	17.8	19.4
Other beef cattle	5.5	5.6	5.8	6.3	6.7	6.3	6.2	6.1
Chickens	7.3	7.9	8.8	9.3	10.3	11.1	10.8	9.3
Broilers	4.6	5.2	6.8	6.8	8.9	9.5	9.8	7.4
Turkeys	1.3	1.5	1.6	1.8	2.2	2.4	2.4	1.9
Hogs	22.1	27.2	32.6	34.5	40.2	43.9	38.4	34.1
Other livestock 2/	1.0	1.1	1.5	1.4	1.9	2.0	1.5	1.5
Total	69.3	81.2	91.1	97.6	111.0	115.4	104.4	95.8

1/ Preliminary.
2/ Includes unallocated quantities.

Source: (43, Nov. 1981, pp. 30-31).

52 million bushels, or 10 percent. Annual use was expected to increase about 13 percent in 1980/81, reflecting the increased use of corn and corn products in the production of alcohol fuels as well as corn sweeteners.

The volume of corn processed by wet-corn millers increased by 242 percent between 1950/51 and 1979/80 (table 8). The wet-milling process separates the kernel into germ, hull, gluten, and starch. The oil is extracted from the germ, and the germ cake and other byproducts are sold to feed manufacturers. Large quantities of starch are packaged for human consumption or sold to food manufacturers for use in food products such as sauces and gravies, puddings and other confections, and baking powder. Starch is also used for nonedible purposes, such as in textiles, paper, adhesives, cosmetics, high explosives, corn binders in foundries, and various laundry purposes.

About 70 percent of the starch produced by wet millers is converted into corn syrups and sweeteners, and the remainder is used in a variety of food and industrial products. In the early seventies, the industry began producing high fructose corn syrup (HFCS); use has increased rapidly as large commercial users substitute more fructose for sugar in satisfying their sweetener needs. A major soft drink manufacturer announced intentions to substitute fructose for 50 percent of its sweetener requirements, and other manufacturers followed with similar intentions. Changes of this nature are likely to be permanent since food and beverage manufacturers are reluctant to change ingredients. Thus, the quantity of corn used by wet processors will continue to grow to satisfy an expanding demand for HFCS. The amount of expansion, however, will depend mostly on the price of HFCS compared with sugar. Recent sugar prices have favored additional substitution of HFCS for sugar in many food and beverage products (fig. 4).

The other major user of corn is the dry-milling industry. The major products of dry millers are breakfast foods, brewer's grits, and other food products such as cornmeal, hominy grits, and corn flour (see table 8). Production of dry-milling products has increased more slowly than wet-process products and reached a level of 167 million bushels in 1979/80. Breakfast foods accounted for 25 million bushels while other products accounted for 142 million bushels. The leading product is brewer's grits, and the brewing industry currently uses the equivalent of about 50 million bushels of corn in the form of grits and flakes (fig. 4).

The slower growth rate experienced by the dry-milling industry reflects the rather stable per capita consumption of meal and cereal in recent years (table 9). Human consumption of

Table 8--Corn processed into food and industrial products

Year beginning Oct. 1	Break-fast foods	Other dry-milling products 1/	Wet-process products	Alcohol and distilled spirits	Total	Domestic use of products	Export of products
			Million bushels				
1950/51	11	79	133	45	268	258	10
1951/52	12	77	124	27	240	234	6
1952/53	12	77	130	17	236	230	6
1953/54	13	72	128	23	236	228	8
1954/55	13	74	139	22	248	237	11
1955/56	13	76	141	27	257	246	11
1956/57	14	86	140	29	269	250	19
1957/58	14	85	142	27	268	251	17
1958/59	15	92	152	34	293	277	16
1959/60	16	95	154	31	296	278	18
1960/61	17	96	155	33	300	283	17
1961/62	18	102	169	36	324	304	20
1962/63	18	105	179	28	330	312	18
1963/64	19	111	195	26	351	320	22
1964/65	19	110	201	28	358	338	20
1965/66	20	110	204	30	364	347	17
1966/67	21	109	208	33	371	350	21
1967/68	21	104	210	34	369	349	20
1968/69	22	101	207	33	363	347	16
1969/70	22	97	216	31	366	352	14
1970/71	23	105	231	24	383	368	15
1971/72	24	110	246	25	405	394	11
1972/73	24	112	284	29	449	434	15
1973/74	24	115	298	33	470	454	16
1974/75	24	118	333	16	491	478	13
1975/76	24	120	350	21	515	503	12
1976/77	25	123	373	21	542	530	12
1977/78	25	135	402	21	583	570	13
1978/79	25	135	430	21	612	600	12
1979/80	25	142	2/483	20	670	655	15

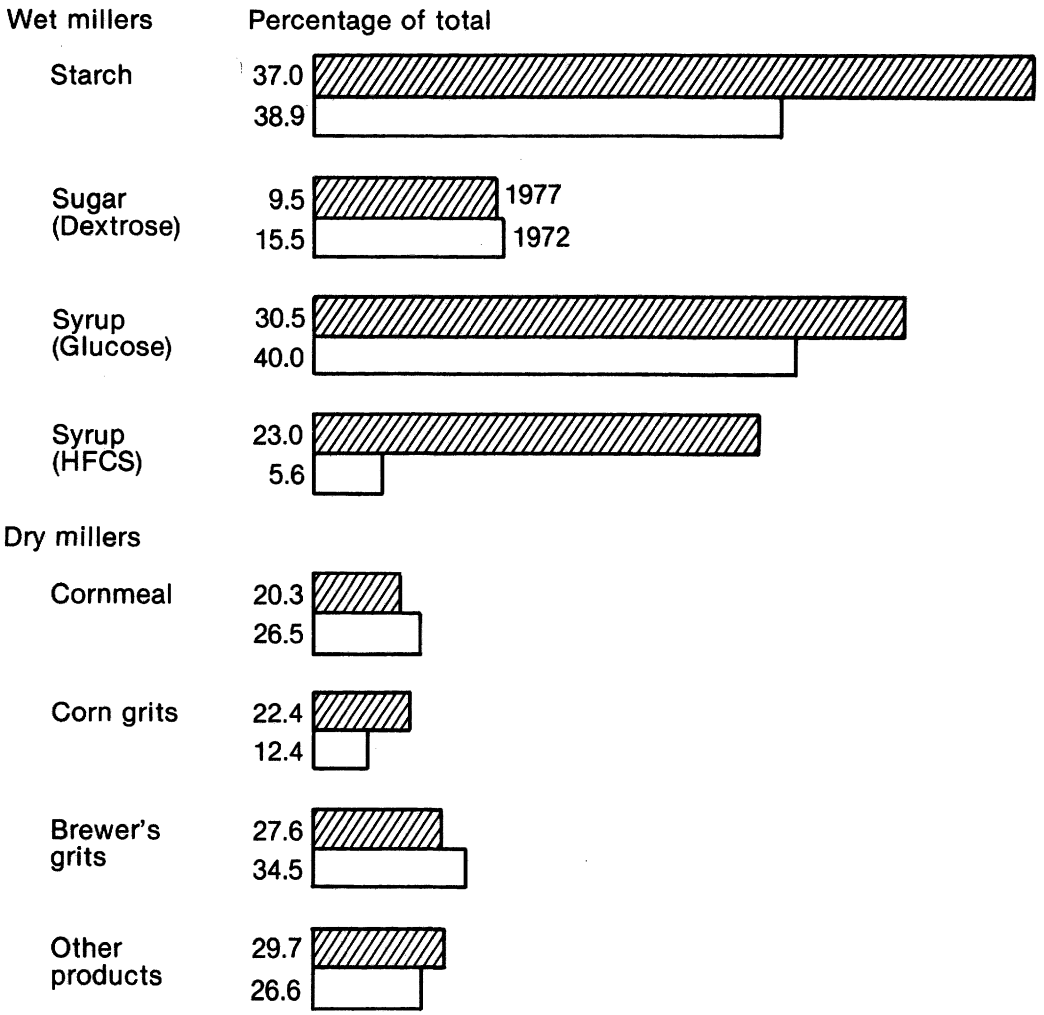
1/ Estimated quantities used in producing cornmeal, flour, hominy grits, brewer's grits, and flakes.

2/ Includes 22 million bushels used in the production of fuel alcohol.

Sources: (39, 43, 44, 46).

Figure 4

Production of Major Products of the Corn Processing Industries



Production	1972	1977
	Million pounds	
Starch	3,588.3	5,486.4
Sugar (Dextrose)	1,432.8	1,404.7
Syrup (Glucose)	3,692.4	4,518.2
Syrup (HFCS)	519.9	3,410.8
Total	9,233.4	14,820.1
Cornmeal	837.6	680.1
Corn grits	392.0	752.4
Brewer's grits	1,088.2	926.9
Other products	837.8	997.8
Total	3,155.6	3,357.2

Source: Bureau of the Census.

Table 9--Total and per capita consumption of corn products as food

Calendar year	Total consumed 1/	Per capita consumption of food products				
		Meal	Breakfast foods	Syrup	Sugar	Starch
	Million bushels	Pounds				
1950	135	11.8	1.5	9.2	4.5	1.9
1951	132	10.8	1.6	9.0	4.1	1.9
1952	130	10.4	1.6	8.7	3.9	1.8
1953	129	9.8	1.6	8.8	4.0	1.8
1954	128	9.3	1.7	8.8	3.8	1.8
1955	132	8.7	1.7	9.0	3.7	2.0
1956	135	8.3	1.7	9.0	3.4	2.0
1957	135	7.9	1.7	8.9	3.2	1.9
1958	141	7.4	1.8	9.5	3.7	1.9
1959	147	7.0	1.8	9.8	3.9	1.9
1960	151	6.6	1.9	10.1	3.7	1.8
1961	155	6.3	1.9	10.6	3.7	1.8
1962	164	6.1	2.0	11.5	3.9	1.8
1963	180	5.9	2.1	12.3	4.5	1.8
1964	188	6.2	2.1	13.6	4.4	1.8
1965	194	6.6	2.2	13.7	4.5	1.8
1966	196	6.9	2.2	14.0	4.6	1.8
1967	202	7.2	2.3	14.1	4.6	1.8
1968	210	7.4	2.3	14.8	4.7	1.9
1969	215	7.4	2.3	15.4	4.9	1.9
1970	220	7.4	2.3	15.8	5.0	1.9
1971	225	7.4	2.3	16.2	5.0	1.9
1972	240	7.4	2.3	18.7	4.8	1.9
1973	261	7.5	2.3	21.7	5.2	1.9
1974	280	7.6	2.3	25.0	5.3	1.9
1975	305	7.7	2.3	28.5	5.5	1.9
1976	330	7.7	2.3	32.0	5.5	1.9
1977	345	7.7	2.3	34.0	5.5	1.9
1978	365	7.7	2.3	34.7	5.5	1.9
1979	369	7.7	2.3	34.7	5.5	1.9

1/ Excludes quantities used in alcoholic beverages. Includes an allowance for the quantity used as hominy and grits.

Source: (39).

cornmeal and cereal appears to have peaked at 10 pounds per capita annually. In contrast, the per capita use of corn syrup in the United States has more than doubled since 1971. Annual use currently stands at 34.7 pounds per capita.

Exports of processed corn products have ranged from 12 million to 15 million bushels (grain equivalent) in recent years. Cornmeal is the most important product exported in terms of volume, and about 30 percent of the exports of that product is for relief or charity. Exports of cornmeal currently account for about 9 million bushels, down from 16 million bushels in 1966/67 (table 10). Exports of wet-milling products have ranged from 3 to 6 million bushels since 1968/69, a relatively small proportion of the total output of that industry.

The cost of corn as an input to the milling industries is only a small part of the total cost incurred in the processing of corn into finished products. Therefore, the quantity used by these industries is not very price responsive. Generally, wet-corn millers operate at full capacity, which has been increasing at an annual rate of approximately 4 to 5 percent, a stable trend correlating closely with population growth.

Seed

Seed use is a relatively small proportion of domestic use. The rapid increase in seed use in the seventies (currently about 20 million bushels) has been associated with an increase in planted acres (see table 6). Also in recent years, a larger quantity of seed was planted per acre than before in response to research indicating that higher plant populations per acre generally result in higher average yields. The optimum plant population depends upon the variety planted, climatic condition, and production practices used by farmers in the different production regions.

Alcoholic Beverages

Use of corn by the brewing and distilling industries has remained fairly stable since 1966, annually accounting for about 70 million bushels (see table 6). Distillers used less corn in recent years, but the declines were offset by increases in the quantity used by brewers. Distillers annually use about 20 million bushels of corn. Use of corn in the form of brewer's grits and flakes has increased steadily since 1955/56. The brewing industry is currently using more than 50 million bushels annually (see table 8). The dry-milling industry produced more brewer's grits than any other corn product during the seventies. Increased demand for brewer's grits will likely continue along with the forecasted expansion of the brewing industry. This expansion will also benefit the wet-processing industry since brewers also use starch grits, dextrose, and corn syrups.

Table 10--Exports of selected corn products

Year beginning Oct. 1	Dry-milling products		Wet-milling products		
	Cornmeal 1/	Hominy grits	Starch	Sugar (dextrose)	Syrup (glucose)
	1,000 bushels (grain equivalent)				
1966/67	16,477	1,245	N.A.	N.A.	N.A.
1967/68	14,970	1,275	N.A.	N.A.	N.A.
1968/69	9,996	1,536	1,915	1,180	669
1969/70	9,239	1,928	1,522	1,085	426
1970/71	7,915	4,309	1,385	1,015	419
1971/72	5,486	1,758	1,394	1,571	357
1972/73	8,004	2,114	1,896	2,310	391
1973/74	8,458	1,641	2,676	2,383	480
1974/75	5,781	1,275	3,229	2,346	468
1975/76	6,441	1,124	2,011	2,145	466
1976/77	5,913	1,100	2,396	1,713	500
1977/78	7,116	1,397	2,063	1,460	507
1978/79	6,007	1,176	2,474	2,071	534
1979/80	6,911	2,178	2,347	3,031	947

N.A. = not available.
1/ Relief programs and commercial sales.
Sources: (43, May 1979, p. 22, 50).

Energy shortages and rapidly increasing prices of gasoline have prompted interest in producing fuel alcohol or ethanol from corn. Gasohol, a blend of 90-percent gasoline and 10-percent grain ethanol, can be burned in conventional automobiles. Processors would require about 200 million bushels of corn to

make 500 million gallons of ethanol for use as gasohol. Development of a successful alcohol fuels industry could substantially increase the industrial demand for corn in the United States.

Exports

The second major component of total U.S disappearance is export demand. Exports have had a significant impact on U.S. corn markets in recent years. The price instability of the seventies reflects the variability in exports as well as variability in domestic production. Exports averaged about 13 percent of total annual disappearance between 1962 and 1972. Since 1972, exports have averaged approximately 27 percent of annual disappearance. The primary importers of U.S. corn are Western Europe and Japan, which together imported 51 percent of total U.S. corn exports in 1979/80.

During the fifties, corn exports averaged about 150 million bushels per year and accounted for only 5 percent of total disappearance on average. Exports averaged about 517 million bushels during the sixties and accounted for about 12 percent of total disappearance. The 1965/66 export level of 687 million bushels was not exceeded until 1971/72, when exports began to expand rapidly. In 1973/74, more than 1.2 billion bushels were exported, representing a 143-percent increase in only 2 years. Exports remained fairly stable until 1975/76 when over 1.7 billion bushels were exported. Exports decreased slightly in 1976/77 and then rebounded to a record of more than 2.4 billion bushels in 1979/80. Exports decreased slightly in 1980/81.

Importing countries use corn primarily for feeding livestock. The value of the dollar relative to foreign countries, trade policies, tariffs, import quotas, embargoes, and other political agreements have a considerable influence on the annual volume exported.

Trends in Demand

Generally, feed use increased rapidly prior to 1974/75, reflecting growth in consumer demand for fed beef and other livestock products. However, overproduction in beef caused meat prices in general to fall dramatically after August 1973. Thus, the combination of depressed livestock prices and high corn prices caused feed use to fall to 3.2 billion bushels in 1974/75, down from the record high of 4.3 billion bushels in 1972/73. Since that time, feed use has rebounded to record levels and should continue to grow with future expansion in the livestock and poultry industries.

Export levels exhibited the most dramatic changes and more than tripled between 1971/72 and 1979/80. Market analysts feel that exports will grow more rapidly than domestic uses in the future.

Use of corn for food in the United States has increased every year since 1954, a trend expected to continue. Growth in food use is generated mostly by an increasing demand for corn sweetener products. The growth potential for producing ethanol from corn depends upon Government policies and programs affecting that industry.

THE CORN MARKETING SYSTEM

Many intermediate marketing and processing firms are involved in assembly, handling and storing, grading and inspecting, merchandising, and processing corn as it moves from farms to final users. The volume of corn marketed from U.S. farms has expanded rapidly in recent years, and this has led to rather substantial changes in the marketing system (12, 58) (fig. 5).

Overview of Marketing Flows

Country elevators traditionally have been the primary outlet for corn sold from U.S. farms, annually accounting for about 80 percent of the volume. The proportion handled by these firms declined from 82 percent in 1959/60 to about 78 percent in 1977. Although the share declined, the volume handled by these firms increased from about 1.4 billion bushels in 1959/60 to almost 4 billion bushels in 1979/80. Terminal elevators and dealers currently account for about 16 percent of the corn sold from farms; however, about 60 percent of the volume of corn handled by terminal elevators is shipped from country elevators.

Country, subterminal, and terminal elevators handle, store, blend, and merchandise and are the primary sources of corn shipped to feed manufacturers, processors, and exporters. The rapid expansion in marketing during the sixties and seventies led to the construction of large subterminal elevators in the regions of concentrated production. As a result, the volume handled by firms in traditional terminal markets failed to increase a great deal. 3/ These markets currently handle about a fourth of the estimated volume of subterminal and terminal elevators.

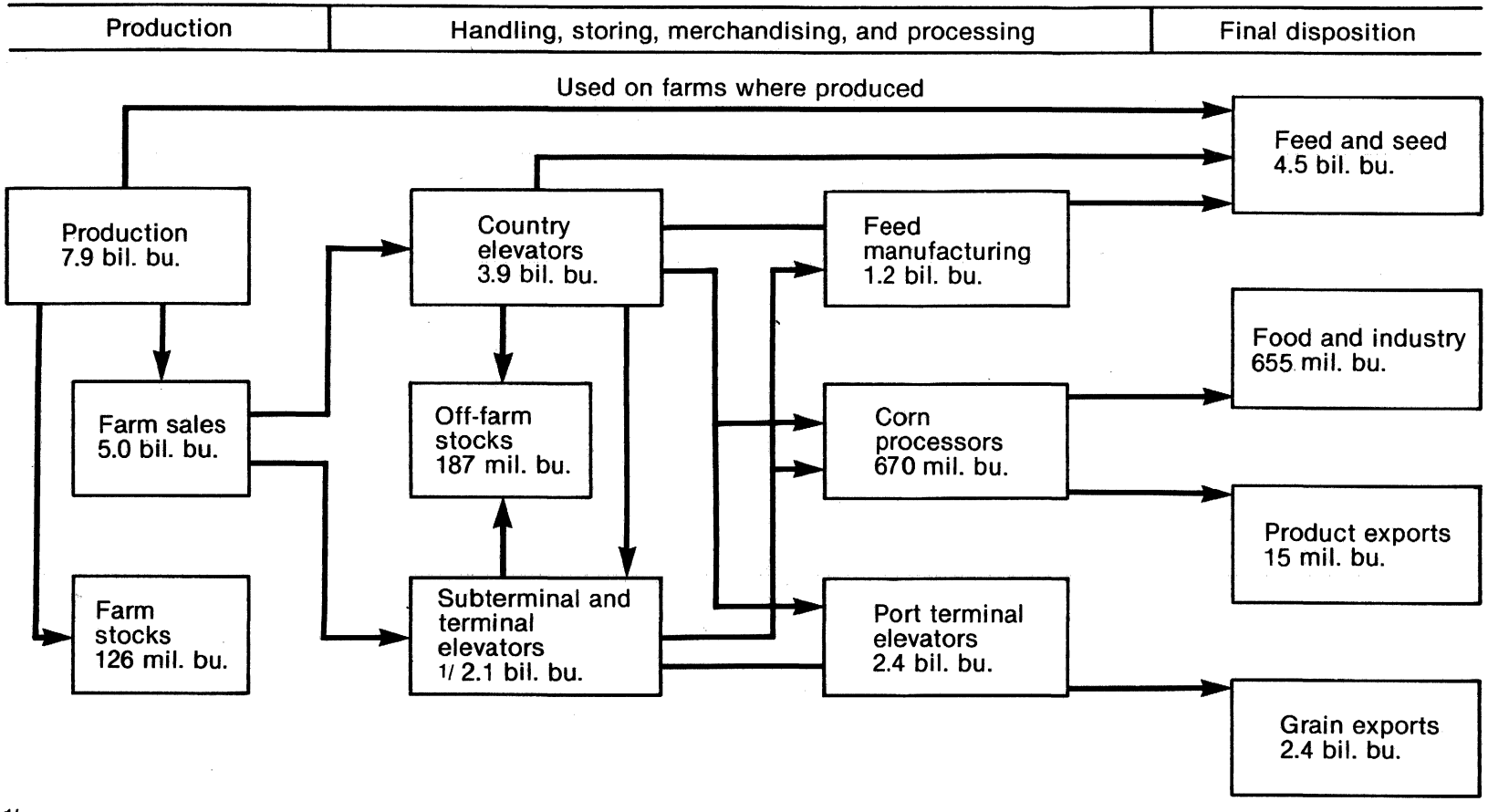
The feed manufacturing industry annually accounts for about a fourth of the corn used as livestock and poultry feed. This industry also purchases feed byproducts of corn processors.

The rapid expansion in the volume of corn exported during the seventies had the greatest impact on market flows. About half the corn sold from U.S. farms in 1979/80 was shipped by country and terminal elevators to port elevators, greatly increasing volume and placing tremendous demands on the system for marketing and transporting grain in the United States.

3/ The traditional terminal markets are Chicago, Kansas City, Milwaukee, Omaha, Peoria, St. Joseph, St. Louis, and Toledo.

Figure 5

Following Corn Through the Marketing Process, 1979/80 Marketing Year



1/ Includes dealers and brokers.

Farm Handling and Storage

The widespread use of the combine with a corn head has substantially changed corn handling methods. Harvest dates have been advanced, causing the moisture content of newly harvested corn to be too high for safe storage. The grain must be artificially dried on the farm or at the elevator. The proportion of production artificially dried onfarm has averaged at least 75 percent in major corn producing States.

The rapid expansion in production during the seventies resulted in a substantial increase in farm storage capacity for grain. As of April 1, 1979, a total of 9.9 billion bushels of grain storage capacity was on U.S. farms, and 40 percent of this capacity was located in Illinois, Iowa, and Minnesota (table 11). Nebraska ranked fourth in capacity at 833 million bushels. About 82 percent of farm storage capacity was suitable for storing shelled corn, and another 11 percent was designated as permanent ear-corn storage.

Expansion in farm storage and shifts in seasonal sales patterns substantially increased the volume stored on farms during the late seventies (table 12). Drought conditions in 1974 led to a sharp reduction of farm stocks in 1975. Farm stocks increased steadily since then, and by Jan. 1, 1980, a record 4.9 billion bushels were stored on farms (52).

Farm Marketings

The marketing season for corn varies by location. In Florida, Louisiana, Oklahoma, and Texas, the marketing season runs from August 1 to July 31. The marketing season is September 1 to August 31 in the South and Southwest. The marketing season in major corn producing States runs from October 1 to September 30.

Seasonality of Marketings

Although some producers routinely market all their corn at harvest, others put a substantial part of their production in onfarm storage facilities. This corn is either fed to livestock or sold at a later date. The recent sizable increase in onfarm storage capacity has given producers greater flexibility in their marketing programs (table 13). As a result, increasing quantities of corn have been dried and placed in storage at harvest for marketing at a later date. In 1965/66, producers sold about 900 million bushels, almost 45 percent of open market farm sales during the fall. In 1979/80, over 1.6 billion bushels were sold in the fall, accounting for 33 percent of total marketings. The proportion marketed in the winter and spring quarters increased accordingly, and in 1978/79, 48.1 percent of off-farm sales of corn were made during that 6-month period. In 1979/80, producers reduced sales during the winter and spring and marketed almost a fourth during the summer when prices were more attractive.

Table 11--Grain storage capacity, 1979 grain production, and stocks by position, Jan. 1, 1980

Selected State	Estimated capacity			1979 production				Total stocks by position, Jan. 1, 1980		Use of capacity
	Onfarm facilities 1/	Off-farm facilities 2/	Total	Corn	Soybeans	Other grains 3/	Total	Onfarm	Off-farm	
	Million bushels									Percent
Iowa	1,494	705	2,199	1,664	306	66	2,036	1,386	537	87
Illinois	1,154	825	1,979	1,414	379	75	1,868	977	584	79
Nebraska	833	533	1,366	822	55	261	1,138	833	356	87
Indiana	507	291	798	675	159	51	885	437	193	79
Minnesota	1,192	393	1,585	606	163	216	985	834	255	69
Ohio	292	272	564	417	145	83	645	277	186	82
Wisconsin	393	129	522	317	10	59	386	302	72	72
Missouri	346	225	571	240	184	131	555	249	156	71
Michigan	188	99	287	238	30	42	310	174	65	83
South Dakota	443	91	534	211	6	191	408	387	62	84
Kansas	366	844	1,210	172	41	662	875	335	429	63
Texas	266	753	1,019	132	21	400	553	240	208	44
12 States	7,474	5,160	12,634	6,908	1,499	2,237	10,644	6,413	3,103	75
Other States	2,473	1,930	4,403	1,031	769	1,616	3,416	1,579	991	58
U.S. total	9,947	7,090	17,037	7,939	2,268	3,853	14,060	7,992	4,094	71

1/ Estimates based on survey of farmers on Apr. 1, 1978.
2/ Revised estimates as of Jan. 1, 1981.
3/ Wheat, sorghum, oats, and barley.

Sources: (42, Jan. 81; 52, Jan. 81; 53).

Table 12--Onfarm stocks of corn, by quarter 1/

Year	Stocks on--			
	Jan. 1	Apr. 1	June 1 2/	Oct. 1
	1,000 bushels			
1970	3,320	2,222	1,403	569
1971	2,730	1,861	1,169	425
1972	3,493	2,447	1,568	745
1973	3,674	2,375	1,366	403
1974	3,353	2,012	1,061	287
1975	2,533	2,214	801	190
1976	3,179	1,910	1,284	231
1977	3,317	2,114	1,564	446
1978	3,824	2,517	1,849	659
1979	4,517	3,098	2,262	776

1/ Data for 1935-69 are available in references 28, 29, and 30.
2/ Prior to 1975, stocks reported are July 1 inventories.
Source: (52).

Farm Marketing Channels

Producers sold about 4 billion bushels of corn during 1977/78. The percentages of total sales moving to selected outlets during calendar year 1977 are presented in table 14. The percentage sold to local elevators ranged from a low of 13 percent in New York to a high of 99 percent in South Carolina, and averaged 78 percent for the 23 States. Sales directly to terminal elevators accounted for 13 percent of the total farm sales in the United States. In Indiana, Kentucky, and Michigan, direct sales to terminals accounted for 25 percent or more of off-farm sales. Sales to other farmers and ranchers amounted to over a third of sales in Colorado and New York. New York was the only State where grain dealers were the most important outlet. Commercial feedlots were an important marketing channel in Kansas and South Dakota, accounting for about 20 percent of off-farm sales.

Assembly and Storage

Country and inland terminal elevators perform the marketing functions of assembly and storage. As noted, most of the corn produced is assembled into economical units for shipment to processors and inland and port terminal elevators. Country elevators also store and distribute grain back to farmers at many locations.

Table 13--Percentage of open farm marketing sales of corn

Month/ season	Crop marketing season				
	1965/66	1971/72	1977/78	1978/79	1979/80
			Percent		
August	0.2	0.3	0.3	0.4	0.5
September	2.6	3.1	1.6	1.8	1.7
October	14.1	12.9	11.6	11.6	9.2
November	18.7	16.5	13.9	11.6	12.9
December	9.2	8.6	9.2	6.5	8.7
Fall 1/	44.8	41.4	36.6	31.9	33.0
January	9.6	8.5	10.6	11.2	9.7
February	7.4	7.0	7.5	7.5	6.8
March	5.9	6.7	8.6	7.1	7.1
Winter	22.9	21.2	26.7	25.8	23.6
April	5.8	5.5	7.2	7.4	5.7
May	5.2	5.4	6.7	6.8	6.1
June	6.2	6.8	6.9	8.1	7.0
Spring	17.2	17.7	20.8	22.3	18.8
July	5.5	7.1	5.3	8.8	8.7
August	5.9	6.7	5.8	6.8	8.6
September	3.7	4.9	4.8	4.4	7.3
Summer 1/	15.1	18.7	15.9	20.0	24.6
Year	100.0	100.0	100.0	100.0	100.0

1/ Some States include August and September in different seasons.
Source: (47).

A large proportion of country elevator receipts are purchased by the elevator owner. Shipments of corn from country elevators generally move to feed manufacturers and inland and port terminals. Shipments directly to port terminals occur most often when the country plant is either owned by, or affiliated with, a major exporting firm. Independent country elevators usually sell to local feed manufacturers and/or inland terminals. These inland facilities generally have the capability to blend, grade, and ship large lots of grain by barge and unit train directly to port elevators. Therefore, inland elevators are the primary suppliers to wet-corn

Table 14--Corn for grain, producer sales, percentage marketed by channels, 1977

State	Local elevators	Terminal elevators	Other farmers and ranchers	Dealers	Commercial feedlots 1/	Other 2/
			Percent			
Alabama	90	10	0	0	0	0
Colorado	55	0	34	4	4	3
Georgia	82	0	13	3	2	0
Illinois	82	16	0	2	0	0
Indiana	65	25	5	5	0	0
Iowa	83	11	4	2	0	0
Kansas	75	1	1	1	22	0
Kentucky	62	29	2	3	0	4
Maryland	84	14	0	2	0	0
Michigan	70	28	1	1	0	0
Minnesota	89	3	7	1	0	0
Missouri	93	3	2	2	0	0
Nebraska	81	0	16	0	3	0
New York	13	0	38	46	3	0
North Carolina	76	19	3	2	0	0
Ohio	82	17	1	0	0	0
Pennsylvania	74	8	6	12	0	0
South Carolina	99	0	1	0	0	0
South Dakota	64	2	14	0	20	0
Tennessee	83	0	6	11	0	0
Texas	93	0	0	1	6	0
Virginia	75	0	16	9	0	0
Wisconsin	69	9	12	6	0	4
23 States	78	13	4	3	2	0

1/ Livestock feeding operations whose primary purpose is to feed and market livestock.

2/ Sales through marketing associations or pools, to seed companies, or other farmers and ranchers, if not shown separately.

Source: (54).

processors and dry-corn millers who have more precise quality needs relative to other users.

Storage contributes the necessary function of distributing the available supplies throughout the marketing year (table 15). This service is provided by farmers, country elevator operators, and inland terminal operators. In contrast, processors and port terminal operators usually have capacity to store working inventories only, making them dependent upon a continuous flow of corn from country and inland terminal elevators to maintain their working inventories.

Inspection and Grading

Corn trading requires inspection and grading services performed by either Federal or State inspection agencies. Most country elevators do not have official weights and grades, so sales are generally made on the basis of destination weights and grades. All inland terminals and port terminals have official weights and grades, which serve as a basis for establishing price on receipts from country elevators. Most sales by inland terminal operators are made on the basis of origin weights and grades. Most lots are reinspected when they arrive at the point of processing or export. The buyer may appeal to the Federal Grain Inspection Service (FGIS) and have the lot regraded by a Federal inspector in cases where origin and destination grades for a particular lot differ significantly.

Grading standards are essential to the marketing of U.S. corn. A uniform definition is needed for specifying quality in futures contracts, storage contracts (warehouse receipts), and sales contracts between buyers and sellers. Standards provide a basis for market quotations and market price reports and provide a means of establishing market premiums and discounts.

Classes of Corn

The Official United States Standards for Grain (55) divides corn into three classes:

- Yellow corn -- Yellow-kerneled corn containing not more than 5 percent of corn of other colors.
- White corn -- White-kerneled corn containing not more than 2 percent of corn of other colors, and
- Mixed corn -- Corn which does not meet the color requirements of either of the classes Yellow corn or White corn.

Grading Factors

Six quality levels of corn are specified in the standards: U.S. Nos. 1, 2, 3, 4, 5, and sample grade. Grades are

Table 15--Off-farm grain storage capacity, by type of facility, Jan. 1980

Region and State	Public warehouses 1/			Private storage 2/	Total capacity 3/
	Country elevators	Terminal elevators	Port elevators		
	1,000 bushels				
Northeast:					
New Jersey	0	0	0	2,430	2,430
New England	1,267	0	0	3,903	5,170
Delaware	2,930	0	0	15,280	18,210
Maryland	1,243	0	13,335	31,182	45,760
New York	0	20,656	14,000	29,704	64,360
Pennsylvania	2,510	0	6,238	22,422	31,170
Subtotal	7,950	20,656	33,573	104,921	167,100
Lake States:					
Michigan	41,043	9,150	5,000	43,807	99,000
Wisconsin	20,645	5,053	53,768	49,904	129,370
Minnesota	210,759	122,564	25,800	33,677	392,800
Subtotal	272,447	136,767	84,568	127,388	621,170
Corn Belt:					
Ohio	98,224	69,327	18,975	85,804	272,330
Indiana	121,890	46,595	0	122,775	291,260
Illinois	568,617	64,891	58,758	132,924	825,190
Iowa	566,424	61,613	0	77,113	705,150
Missouri	105,975	77,534	0	41,221	224,730
Subtotal	1,461,130	319,960	77,733	459,837	2,318,660
Northern Plains:					
North Dakota	127,348	17,388	0	1,504	146,240
South Dakota	82,543	2,242	0	5,775	90,560
Nebraska	391,491	130,098	0	11,811	533,400
Kansas	485,953	316,367	0	41,680	844,000
Subtotal	1,087,335	466,095	0	60,770	1,614,200
Appalachian:					
Virginia	30	0	10,329	27,631	37,990
West Virginia	0	0	0	550	550
North Carolina	25,368	0	0	48,852	74,220
Kentucky	11,123	9,948	0	32,559	53,630
Tennessee	25,049	8,338	0	18,783	52,170
Subtotal	61,570	18,286	10,329	128,375	218,560
Southeast:					
South Carolina	9,862	0	1,500	22,598	33,960
Georgia	23,252	0	0	42,668	65,920
Florida	2,022	0	0	5,548	7,570
Alabama	15,120	2,350	2,200	19,340	39,010
Subtotal	50,256	2,350	3,700	90,154	146,460

See footnotes at end of table.

Continued--

Table 15--Off-farm grain storage capacity, by type of facility, Jan. 1980--Continued

Region and State	Public warehouses1/			Private storage2/	Total capacity3/
	Country elevators	Terminal elevators	Port elevators		
	1,000 bushels				
Delta States:					
Mississippi	28,285	6,131	3,100	39,984	77,500
Arkansas	127,578	48,189	0	36,053	211,820
Louisiana	26,535	0	39,628	29,987	96,150
Subtotal	182,398	54,320	42,728	106,024	385,470
Southern Plains:					
Oklahoma	122,736	77,516	0	8,728	208,980
Texas	390,054	227,811	65,900	69,235	753,000
Subtotal	512,790	305,327	65,900	77,963	961,980
Mountain:					
Montana	43,131	4,405	0	6,214	53,750
Idaho	55,393	732	0	18,945	75,070
Wyoming	3,366	0	0	3,794	7,160
Colorado	57,104	13,292	0	24,654	95,050
New Mexico	15,896	0	0	844	16,740
Arizona	9,086	0	0	25,924	35,010
Utah	1,298	9,917	0	6,795	18,010
Nevada	0	0	0	300	300
Subtotal	185,274	28,346	0	87,470	301,090
Pacific:					
Washington	142,877	0	35,690	12,523	191,090
Oregon	38,978	1,974	12,395	11,443	64,790
California	41,423	11,280	8,860	38,347	99,910
Subtotal	223,278	13,254	56,945	62,313	355,790
Total capacity	4,044,428	1,365,361	375,476	1,305,215	7,090,480

1/ Capacity of warehouses operating under a uniform grain storage agreement with Commodity Credit Corporation.

2/ Off-farm grain storage capacity not covered by a grain storage agreement with Commodity Credit Corporation.

3/ Rated off-farm storage capacity as reported by USDA's Crop Reporting Board, Statistical Reporting Service.

Source: Agricultural Stabilization and Conservation Service, U.S. Department of Agriculture, Operating Report TW-5R and (52, Jan. 1981, p. 31).

determined on the basis of factors specified in the standards. Factors currently used in grading are:

- Test weight per bushel, which reflects density of the grain and is expressed as weight per Winchester bushel.
- Moisture, which is a measure of the amount of dry matter in corn and also reflects the storage life of a particular lot.
- Broken corn and foreign material (BCFM), which is defined as kernels and pieces of kernels of corn and all matter other than corn which will pass readily through a 12/64 sieve, and all matter other than corn which remains in the sieved sample.
- Damaged kernels, which are defined as kernels and pieces of kernels of corn damaged from heat, sprouted, frosted, badly ground damaged, badly weather damaged, moldy, diseased, or otherwise materially harmed.
- Heat-damaged kernels, which are kernels and pieces of kernels of corn materially discolored and damaged by heat.

Grade Designation

Grade designations for corn are based on maximum or minimum limits for each of the above factors. The requirements for each grade are shown in table 16. The lowest factor approach is used in determining grades. For example, a grade designation of U.S. No. 3 would be assigned based on a sample containing 3.5-percent BCFM, even though all other factors meet the requirements of U.S. No. 1. This approach has been used since the inception of grading standards, but a major disadvantage is that it does not reflect true quality through other attributes that enhance the relative values of a particular lot.

Processing

Major U.S. corn processors are the prepared animal feed (PAF) manufacturers, wet-corn processors, and dry-corn millers. The marketing process for cash corn is completed with the purchase by these processors. In purchasing grain, processors select the class and grade adapted for making their particular products.

PAF Manufacturers

The PAF manufacturing industry is the most important user of corn in terms of volume. The industry annually processes about a fourth of the corn used for livestock feed in the United States, combining grain, oilseed meals, grain byproducts, animal protein, vitamins, minerals, and other feed ingredients in the production of formula feed. Formula feeds are a combination of two or more ingredients that are processed or mixed according to specifications.

Table 16--Official U.S. grading standards for corn grades, grade requirements, and grade designations

Grade	Minimum test weight per bushel	Maximum limits of--			
		Moisture	Broken corn and foreign material	Damaged kernels	
				Total	Heat-damaged kernels
	Pounds	Percent			
U.S. No. 1	56	14.0	2	3	0.1
U.S. No. 2	54	15.5	3	5	.2
U.S. No. 3	52	17.5	4	7	.5
U.S. No. 4	49	20.0	5	10	1.0
U.S. No. 5	46	23.0	7	15	3.0
U.S. sample grade	U.S. sample grade corn does not meet the requirements for any of the grades from U.S. No. 1 to U.S. No. 5, inclusive; or contains stones; is musty, sour, heating; has any commercially objectionable foreign odor; or is otherwise of distinctly low quality.				

Source: (55, pp. 2.1-2.5)

The combination of feed ingredients used by feed manufacturers varies by location and is determined by the nutritive value of the alternative ingredients, the relative price of these ingredients, and the nutritive specification of the feed being produced. Information on the ingredients used by the industry in 1969 and 1975 was collected through industry surveys (table 17). Corn represented 29 percent of total ingredients used by the industry in 1969 and about 37 percent of total ingredients used in 1975.

Products of this industry are complete feeds, feed supplements, and premixes. Complete feeds contain all nutrients needed in the nonroughage portion of the diet of a particular class of livestock. Supplements are formula feeds used with other feed ingredients to improve the nutritive balance of the diet. They may be fed separately as a dietary supplement or mixed with grain and other feed ingredients to formulate a complete feed. Premixes are formulations of one or more microingredients

Table 17--Feed ingredients used by primary feed manufacturers

Feed ingredient	1969	1975
	1,000 tons	
Grains:		
Corn	19,787	25,979
Sorghum	7,589	5,593
Barley	2,441	2,381
Oats	1,697	1,712
Wheat	819	759
Subtotal	32,333	36,424
Oilseed meals:		
Soybean	10,686	9,841
Cottonseed	1,496	1,112
Other	326	366
Subtotal	12,508	11,319
Grain byproducts:		
Brewer's dried grains	416	429
Distiller's dried grains	450	569
Corn gluten feed	718	461
Corn gluten meal	382	749
Hominy feed	866	697
Wheat mill feed	4,197	3,523
Other mill feeds	759	1,628
Subtotal	7,788	8,056
Animal protein meals	3,287	3,095
Minerals	2,928	2,646
All other ingredients	9,688	7,989
Total	68,532	69,529

Sources: (59, 60).

(vitamins, trace minerals, or drugs) mixed with a carrier. A premix is used to distribute microingredients evenly throughout a formula feed.

Primary manufacturers accounted for about 70 percent of the formula feed produced in 1975 (60, p. 31). The complete feed balance was produced by secondary manufacturers who mix supplements and premixed products from primary manufacturers with grains and other ingredients. Data are not available on ingredients used by these firms. Consequently, corn used by these firms is not included in table 17.

In 1975, 6,340 feed manufacturing establishments produced 104.5 million tons of formula feed (60, p. iii). About 30 percent of the feed manufacturing establishments were located in the Corn Belt as follows:

Location of feed manufacturing firms

Region	Proportion of total production	Proportion of total manufacturing firms
	Percent	
Northeast	11	10
Appalachian	7	7
Southeast	9	6
Lake States	10	14
Corn Belt	18	30
Delta States	6	3
Northern Plains	9	14
Southern Plains	12	7
Mountain	8	5
Pacific	10	4

The Lake States and Northern Plains had the next largest number of establishments, each with 14 percent. Only 4 percent of the establishments were located in the Pacific States, but those facilities accounted for 10 percent of feed production in 1975. Average output per facility in that region ranged over 40,000 tons during 1975.

Wet-Processing Industry

The wet-processing industry is the second most important processor of U.S. corn, in terms of volume. The industry uses shelled corn in the manufacture of a diversified group of products including starch, dextrin, corn syrup, corn sugar, corn oil, and byproduct feed ingredients.

In 1975, the industry was composed of 12 companies operating 17 plants--14 in the Corn Belt, 2 in Texas, and 1 in Pennsylvania (23). Between 1967 and 1975, five new corn refining plants were constructed by companies in the industry, and two less efficient plants were closed. New plants have been constructed in Alabama and New York since 1975, and others have been expanded to meet a growing consumer demand for the products.

Corn received at a wet-milling plant is cleaned to remove BCFM and either put in storage or moved directly into the milling process. The first step in wet processing involves soaking or steeping the corn in a slightly acidified warm water solution to soften the hull and prepare the kernel for the milling process. The steeping process lasts 36 to 48 hours. The milling process separates the corn kernel into four distinct parts: the germ, hull, gluten, and starch.

After steeping, the softened corn moves to degerminators for removal of the germ. The germ, which contains most of the oil, is processed to extract the oil. After the oil is removed, the residue is ground and mixed with other byproducts to make corn gluten feed or is sold separately as germ cake. The crude corn oil can be used in soaps, paints, varnishes, and other products. However, it is generally refined for use in salad and cooking oils and for use by processors of salad dressings, margarine, and other foods.

The hulls are separated from the starch and gluten. They are then dried and become part of the corn gluten feed sold to PAF manufacturers. Gluten feed usually contains the germ cake, hulls (fiber), solubles, and BCFM.

Once the hulls are removed, the starch and gluten remain in suspension in a slurry. The gluten particles are lighter than the starch particles and are easily separated by centrifugal force. Most of the gluten is sold as corn gluten meal and used by feed manufacturers. Some is usually combined with the germ cake meal and hulls to be sold as corn gluten feed. Gluten also has several industrial uses, for example, glutamic acid, which is used to produce monosodium glutamate, a common seasoning for food.

Once the gluten is removed, the starch is purified and dried, then is either packaged for market or further processed into a variety of products such as dextrins, syrups, and sugars. Corn starch is used in a wide variety of food products as well as industrial products. About 70 percent of the starch produced by the industry is converted to corn sweeteners, syrups, and sugars.

The wet-milling process recovers almost all the dry matter present in whole corn. According to Watson, about 98 percent of the dry matter is recovered in salable products (62). The yield and average chemical composition of products produced in the wet-milling process are presented in table 18. Starch is the major volume product from wet milling and represents about 69 percent of the products recovered (67.5 percent of total dry matter in corn). The products going into gluten feed

Table 18--Wet-corn milling: Yield and composition of products

Product	Dry product yield	Average composition		
		Starch	Protein	Fat
		Percent (dry basis)		
Whole corn	100.00	71.30	9.87	4.55
Starch	67.50	0	.30	.02
Germ	7.50	7.60	10.70	52.00
Oil, crude 1/	3.86	0	0	0
Germ cake 1/, 2/	3.64	15.70	22.00	1.00
Gluten meal	5.80	18.50	70.00	6.20
Solubles 2/	7.60	0	46.00	0
Fiber 2/	9.50	11.50	11.30	2.80

1/ These products are derived from germ.
2/ These products are usually combined and sold as gluten feed. The BCFM removed from whole corn prior to wet processing is also put in gluten feed.
Source: (62, p. 729).

(germ cake, solubles, and fiber) represent about 21 percent of product yield on a dry basis, with gluten meal and crude corn oil standing at about 5.8 percent and 3.9 percent of total product yield, respectively.

As noted, about 70 percent of the starch produced by the industry is converted into corn sweeteners. In 1972, corn syrup represented about 75 percent of the corn sweeteners produced from starch, and corn sugar made up the balance (62, p. 733). In the early seventies, the industry developed a process of producing HFCS which has sweetness characteristics that make it a viable substitute for common sugar (sucrose) in the manufacture of soft drinks and many other processed food products. This development came at the time of the sugar shortage and record high prices for sucrose in 1974. HFCS was substituted for sucrose in many food products, and the rapidly expanding demand for HFCS led to a significant increase in industry capacity. Most of the processing facilities added by the industry in the seventies manufactured HFCS.

The corn refining industry began as an industry designed to produce corn starch for industrial and food uses, but developed into an industry that uses the whole kernel of corn. Today, the industry is known as a sweetener industry; growth will depend upon a continued expansion of the sweetener market. The greatest potential appears to be in the market for corn syrup sweeteners such as HFCS. The production cost advantage of HFCS compared to sugar should lead to an expanding share of the sweetener market.

Dry-Milling Industry

The dry-milling industry is composed of both small and large plants owned by many firms scattered throughout the United States. The industry began as many small mills, but has declined in number and increased in size of the mill. In 1965, 134 mills operated in the United States; the number declined to 125 in 1971 and to 101 by 1978 (24, 35). Between 1965 and 1978, all but one of the closing mills were located in either Kentucky, Tennessee, North Carolina, or Virginia. These four States currently have 48 operating mills, almost half of the total. In contrast, 10 mills have opened in Illinois and Missouri since 1965.

Watson observed that many of the small mills located primarily in the South produce white cornmeal for home use or for use in making corn chips, tortillas, and other snack items (62, p. 745). Capacity data have not been available in recent years. But in 1965, the Appalachian region had 84 operating mills with an average daily capacity of 429 hundredweight (cwt) (22, p. 79). In contrast, the Corn Belt region had 21 mills, and average capacity was almost 1,000 cwt per day (the largest mill had a capacity of 4,800 cwt).

The milling process of the larger mills involves degermination of the corn kernel (62). The granular material remaining is sorted by size after the bran and germ are removed. The largest pieces are used to produce pearl hominy. In addition to home use as hominy, it is also further processed to produce corn flakes. The smaller pieces of corn are further reduced in size and grouped into uniform particle sizes, producing brewer's grits, hominy grits, granulated cornmeal, and bolted cornmeal. The extremely fine material is sold as corn flour or as a byproduct for animal feed. Sizable quantities of corn flour are used by breakfast food manufacturers.

Dry-corn millers use most of the U.S. white corn to manufacture pearl hominy, brewer's grits, hominy grits, and cornmeal. They also use yellow corn to produce corn flour, creamed or bolted cornmeal, and granulated cornmeal.

Alcohol Fuel Industry

Recent increases in the industrial use of corn in the United States reflects to a large extent the development of an alcohol fuel industry. The Department of Energy and Government subsidies have encouraged the production of ethanol, which is manufactured mostly from corn through dry-milling or wet-processing methods. The grits and starch are used as feedstock for the distilling operation.

Most of the new ethanol plants are located in the Corn Belt where local corn supplies are abundant and prices are favorable. Plants are planned for Oklahoma, Tennessee, and Louisiana because of the availability of low cost water transportation for shipping corn.

Exporting

Exporting is an important marketing function for corn, coming to the forefront during the seventies. Exporters compete with livestock feeders, processors, and distillers for available U.S. supplies.

Exports by Region

The volume of corn exported from the United States topped 500 million bushels for the first time in 1964/65 and remained fairly stable through the 1970/71 marketing year when exports of grain totaled 487 million bushels. During the following 9 years, shipments of U.S. corn exports more than quadrupled, reaching a record 2.4 billion bushels in the 1979/80 marketing year (table 19).

The growth in export demand since 1970/71 brought about some notable shifts in the location of export activity. Gulf ports are the predominant outlet for corn exports, currently accounting for about 60 percent of total shipments. The dominance of the gulf region is based on the comparative advantage it enjoys in domestic transportation over the inland waterway system. In calendar year 1977, for example, port elevators on the gulf handled two-thirds of the corn shipped from U.S. ports, and almost 80 percent of volume moving to gulf port elevators was shipped by barge.

The volume handled by port elevators in the Atlantic region increased every year except two during the seventies. The share handled by these elevators peaked at 23 percent in 1976/77. The volume shipped from Atlantic ports has been fairly consistent since that time, declining to 16 percent in 1979/80. Atlantic facilities draw grain from the Eastern Corn Belt, and about 90 percent of these movements are by unit train.

The increasing market share of Atlantic port facilities during the early seventies came at the expense of Great Lakes ports. The share of exports handled by Great Lakes elevators declined

Table 19--Corn inspected for export, by region1/

Year beginning Oct. 1	Export region								Total
	Great Lakes 2/		Atlantic		Gulf		Pacific		
	Mil. bu.	Pct.	Mil. bu.	Pct.	Mil. bu.	Pct.	Mil. bu.	Pct.	Mil. bu.
1968/69	127	25	41	8	330	66	1	--	499
1969/70	117	21	65	11	388	68	1	--	571
1970/71	95	20	62	13	327	67	3	--	487
1971/72	139	18	129	17	500	65	1	--	769
1972/73	159	13	235	20	816	67	2	--	1,212
1973/74	115	10	253	21	825	69	3	--	1,196
1974/75	80	7	255	23	757	69	7	1	1,099
1975/76	160	10	374	22	1,154	68	3	--	1,691
1976/77	155	9	391	23	1,130	67	14	1	1,690
1977/78	237	12	384	20	1,179	63	98	5	1,898
1978/79	255	12	417	20	1,265	59	197	9	2,134
1979/80	221	9	387	16	1,450	60	317	13	3/2,406

-- = Less than 0.5 percent.
1/ Excludes export shipments of corn products.
2/ Includes quantities transshipped through Canadian ports located on St. Lawrence Seaway.
3/ Includes 31 million bushels that were inspected at interior points.
Source: (49).

from 25 percent in 1968/69 to 7 percent in 1974/75; the share has ranged from 9 to 12 percent since then.

The St. Lawrence Seaway opened with great fanfare in 1959, and many Great Lake cities such as Chicago and Toledo were expected to become international seaports. However, the economics of transportation have favored movements to gulf and Atlantic ports. Tolls for a typical bulk cargo ship going

through the St. Lawrence Seaway and Welland Canal have more than doubled since 1979 to $30,000 (36, Mar. 24, 1981, p. 1). Two other factors place the seaway at a disadvantage: it is closed for 2 to 3 months during the winter season because of ice, and the draft limitations on the seaway make it necessary for large bulk grain tankers to partially load at Great Lakes ports and finish loading at Canadian ports located on the St. Lawrence River. In 1979/80, for example, nearly 60 percent of Great Lakes exports of U.S. corn was shipped to Canadian ports (primarily Montreal) by lake freighter before transfer to oceangoing vessels. The volume of corn exported through Great Lakes ports is not expected to expand a great deal because the port elevators rely heavily on supplies trucked from nearby production areas. If corn is loaded on railcars, the economics favor movement to Atlantic ports under unit-train rates.

The most dramatic change in port region shares has been the recent increase in volumes handled by Pacific port facilities. The share handled by Pacific ports has increased from less than 1 percent to 13 percent in 1979/80. This growth reflects the introduction of unit-train movements from Nebraska, Iowa, and South Dakota to Pacific ports. This shift also reflects more favorable ocean freight rates from Pacific ports to Southeast Asia compared with gulf port shipments. Pacific port exports are moving to destinations that were traditionally served by gulf ports. Current congestion at gulf ports should encourage further expansion in shipments of corn from Pacific ports.

The combined costs of domestic and ocean transportation from point of production to foreign destination will be the most important factor in determining the share of total exports handled by each port region in the future. Recent trends suggest that volumes handled by gulf and Pacific port elevators will continue to grow as exports expand while the volumes handled by Great Lakes and Atlantic port elevators will be maintained at current levels.

Quality of U.S. Exports

The quality of corn exported from the United States has been of great concern in recent years, mostly centering on the BCFM grading factor. The widespread use of high-temperature drying creates stress cracks in the corn kernel's seed coat, and increases the kernel's susceptibility to breakage during handling operations.

Almost all the corn exported from U.S. ports is inspected at the time it is loaded aboard ships. Export sales are generally made on the basis of quality as determined at origin. Price is based on an understanding of the exporter's limited responsibility. Thus, quality changes during handling, loading, and unloading become the responsibility of the buyer rather

than of the seller. The quantity of corn, by grade, inspected for export at U.S. ports during 1979/80 is shown below (51, Nov. 7, 1980, p. 11).

Grade designation	Quantity
	1,000 bushels
U.S. No. 1	4,059
U.S. No. 2	79,499
U.S. No. 2 or better	372,247
U.S. No. 3	374,146
U.S. No. 3 or better	1,433,639
Other grades	127,128
Not inspected	4,331
White corn	10,720
Total	2,405,769

About 60 percent of the volume exported in 1979/80, a record year for exports, was designated as No. 3 or better, a grade designation which allows for a maximum of 4-percent BCFM when inspected during loading. Additional breakage occurs when the grain is dropped into the ship and when it is unloaded at foreign ports. The amount of breakage depends upon the brittleness of the corn as well as the handling method.

Breakage and BCFM could be reduced by developing improved harvesting, conditioning, and handling methods that reduce brittleness. The cost of developing and adopting new techniques can be justified only if they result in greater value to buyers. The grades currently exported suggest that most foreign buyers are not willing to pay premiums associated with grades 1 and 2. This attitude is probably justified since loading No. 1 corn at U.S. ports does not insure that foreign users will receive whole corn. Unloading corn at foreign ports with pneumatic suckers is almost certain to increase the BCFM content of a shipload of corn (18).

Foreign Destinations for U.S. Corn

U.S. corn has become the foundation of a world livestock economy that is expanding rapidly as efforts to upgrade diets with more meat continue. In 1979/80, U.S. corn was shipped to 95 countries and accounted for 80 percent of total world trade in corn. The volume shipped to various countries ranged from a low of 19,000 bushels for Chad and Togo to a high of 445.8 million bushels for Japan. Twenty-six countries received 10 million bushels or more in 1979/80 (table 20).

Table 20--Quantity of U.S. corn shipped to major foreign destinations

World region and country of destination	Marketing year	
	1978/79	1979/80
	Million bushels	
Asia:		
China	116.3	65.3
Taiwan	86.6	83.3
Israel	11.2	21.5
Japan	360.1	445.8
Korea, Republic of	100.9	84.2
Other	21.2	38.4
Subtotal	696.3	738.5
Western Europe:		
Belgium	62.1	53.3
West Germany	81.5	140.3
Greece	49.2	49.3
Italy	73.5	104.4
Netherlands	98.5	102.6
Portugal	71.4	90.2
Spain	113.0	162.4
United Kingdom	79.0	67.9
Other	6.9	9.7
Subtotal	635.1	780.1
Eastern Europe:		
Bulgaria	4.1	19.7
East Germany	33.6	65.4
Poland	60.8	104.1
Romania	39.1	39.6
USSR	445.7	230.9
Yugoslavia	41.6	.7
Other	2.1	8.9
Subtotal	627.0	469.3
North America:		
Canada	23.9	33.0
Central America:		
Mexico	19.8	141.9
Other	20.7	28.1
Subtotal	40.5	170.0
South America:		
Brazil	55.0	66.1
Chile	1.3	11.6
Peru	3.0	14.4
Venezula	1.7	30.6
Other	3.8	8.7
Subtotal	64.8	131.4
Africa:		
Egypt	22.3	33.2
Tunisia	5.3	10.5
Other	18.3	36.6
Subtotal	45.9	80.3
Other:		
Australia and Iceland	.3	.3
Destination unknown	.6	2.9
Total shipments	2,134.4	2,405.8

Source: (51).

Western Europe has traditionally been the leading destination for U.S. corn exports, and countries in that region received almost one-third of total shipments in 1979/80, a drop from the more than 50 percent of U.S. shipments as recently as 1976/77. This area has been a relatively stable market since 1976/77 and should continue to be so.

Exports to Asian destinations have expanded rapidly in recent years, and in 1978/79 that region led all others, importing almost 700 million bushels. Japan is, by far, the leading destination in that region, accounting for 446 billion bushels, or 60 percent of the Asian total in 1979/80. The Republic of Korea and Taiwan are growing markets. China represents an uncertain market of vast potential; future developments will depend upon Chinese trade policy.

Eastern Europe imported large volumes of U.S. corn during the seventies. The partial embargo on shipments to the USSR in 1980 halted the upward trend in exports to that region. The reduction in shipments to the USSR was partially offset by increased exports to other countries in the region such as Poland.

The largest increases occurred in shipments to Central and South America. Shipments to Mexico (considered in Central America for this report) rose dramatically because of production problems in that country. Shipments to South America more than doubled; however, a sizable proportion of this increase probably replaced Argentine corn which had been diverted from these destinations to the USSR.

Shipments to African nations rose in 1979/80, and some of that volume moved to markets that would normally be supplied from South Africa. Again, the partial embargo had a noticeable impact on usual trading patterns.

DOMESTIC MARKETING PATTERNS AND TRANSPORTATION MODES

Data on the quantities of corn handled at U.S. port facilities and the quantities shipped to various foreign destinations have been published throughout the study period. Statistics on the amounts of corn shipped by barge on inland waterways are also published periodically (51). In contrast, information about corn movements within the United States and about the mode of transportation used to move corn has been limited. This information is normally collected through industry surveys, and all surveys conducted before 1978 were limited to certain geographical regions. For example, a survey of grain movements in 1970 was conducted by the SM-42 Regional Research Committee. That survey involved eight Southeastern and three Corn Belt States (33).

The critical need for better information on grain movements was recognized, and a nationwide study was funded by the Institute of Water Resources of the U.S. Army Corps of Engineers, the Federal Railroad Administration of the Department of Transportation, the U.S. Department of Commerce, and the St. Lawrence Seaway Development Corporation. Through personal interviews with over 3,500 grain merchandisers, processors, and exporters in 41 States, data on origins, destinations, and transportation modes were assembled for corn and other grains in 1977. This project was the first effort to survey grain shippers and receivers nationwide and is the most comprehensive study of grain movements ever conducted. Details on movements to and from substate regions are published elsewhere (17).

Intrastate Movements

In 1977, U.S. grain marketing firms reported shipping more than 6.5 billion bushels of corn. Much of this is accounted for by the same grain being shipped in sequence by several firms. About 36 percent of the amount shipped moved to destinations within the State of origin. These intrastate shipments for each State and mode of transportation are summarized in table 21. Trucks were the predominant mode of transportation, accounting for 75 percent of the total intrastate shipment volume. About 11 percent of the total was shipped by railroads, and almost 14 percent moved to local farmers. Less than 1 percent of the corn shipped within State boundaries was conveyed by barge. A sizable portion of the intrastate movements consisted of shipments from country elevators to terminal elevators for storage and reshipment. Movements within Illinois accounted for more than a fourth of the total volume of intrastate shipments in the United States. Sizable movements also occurred in Iowa and Minnesota.

Interstate Movements

While trucks carried the bulk of intrastate corn shipments, railroads had the largest modal share in interstate shipments, carrying over 1.3 billion bushels, or 49 percent of the total volume (table 22). Over half of the rail shipments originated in Illinois, Indiana, and Nebraska. A large portion of Indiana rail shipments moved to ports on the east coast. The southeastern feed markets also were important destinations. For Illinois, the gulf ports were the principal destinations, but significant quantities went to the east coast and to the southeastern feed markets. California was a principal recipient of Nebraska's rail shipments, although the Arkansas feed market and the Texas ports were also important destinations.

Interstate truck shipments originating in Indiana and Iowa accounted for more than a third of the total volume shipped across State lines by truck. Most of these shipments moved short distances to the neighboring States of Illinois,

Table 21--Intrastate shipments of corn, by State and mode of transportation, 1977 1/

Originating State	Mode of transportation				Total
	Rail	Truck	Barge	Farm truck2/	
			1,000 bushels		
Alabama	1,318	12,946	3,008	3,595	20,867
Arizona	151	2,505	0	0	2,656
Arkansas	16,040	5,083	0	86	21,209
California	173	21,117	0	0	21,290
Colorado	89	7,532	0	0	7,621
Delaware	0	7,448	0	0	7,448
Florida	3,976	2,204	0	120	6,300
Georgia	575	25,569	0	11,210	37,354
Illinois	41,398	573,365	4,196	20,730	639,689
Indiana	2,102	174,806	0	1,860	178,768
Iowa	35,720	258,777	0	205,135	499,632
Kansas	16,516	34,951	0	0	51,467
Kentucky	6,176	5,637	0	0	11,813
Louisiana	0	4,790	0	0	4,790
Maryland	0	14,568	71	0	14,639
Michigan	0	17,445	0	0	17,445
Minnesota	37,709	181,883	0	38,160	257,752
Mississippi	1,775	2,003	0	497	4,275
Missouri	12,767	36,431	0	0	49,198
Nebraska	55,647	141,071	0	41,579	238,297
New York	293	712	0	150	1,155
North Carolina	4,067	48,841	0	0	52,908
Ohio	6,335	117,003	0	0	123,338
Pennsylvania	0	34,598	0	0	34,598
South Carolina	1,230	5,662	0	3,422	10,314
Tennessee	763	10,267	0	2,114	13,144
Texas	28,599	104,514	0	0	133,113
Vermont	0	0	0	4	4
Virginia	95	283	1,970	2,268	4,616
Wisconsin	5,288	15,757	0	2,341	23,386
Wyoming	0	0	0	45	45
U.S. total	278,802	1,867,768	9,245	333,316	2,489,131
			Percent		
Percentage of total shipment volume	11.2	75.0	.4	13.4	100.0

Note: States not having intrastate shipments in 1977 are omitted.

1/ Shipments to port cities within the State are included in these data. Exports to destinations outside the United States are not included.

2/ This column reports sales by elevators to local farmers located within the State. Not all States included farm sales in their questionnaire so these data are incomplete and underestimate total shipments to farmers.

Source: (17, p. 11).

Table 22--Interstate shipments of corn, by State and mode of transportation, 1977 1/

Originating State	Mode of transportation				Total
	Rail	Truck	Barge	Farm truck 2/	
			1,000 bushels		
Alabama	45	1,186	50	0	1,281
Arkansas	60	0	0	0	60
Colorado	7,269	2,053	0	0	9,322
Delaware	0	4,885	1,307	0	6,192
Florida	651	421	117	0	1,189
Georgia	5,715	3,710	0	0	9,425
Illinois	249,291	41,095	526,238	0	816,624
Indiana	285,824	76,648	25,214	217	387,903
Iowa	170,734	91,359	156,891	5,663	424,647
Kansas	27,777	7,443	0	0	35,220
Kentucky	27,602	7,626	46,330	0	81,558
Louisiana	624	118	50	0	792
Maryland	161	7,173	0	0	7,334
Michigan	35,095	31,653	0	0	66,748
Minnesota	33,062	16,514	76,573	380	126,529
Mississippi	0	1,788	0	0	1,788
Missouri	23,970	7,208	31,156	0	62,334
Nebraska	210,489	26,670	1,825	18,477	257,431
New Jersey	0	2,890	0	0	2,890
New Mexico	0	312	0	0	312
New York	2,233	1,511	0	0	3,734
North Carolina	2,617	17,755	2,348	0	22,720
North Dakota	6,777	124	0	0	6,901
Ohio	165,105	9,666	30,804	0	205,575
Oklahoma	92	785	0	0	877
Pennsylvania	291	3,810	0	0	4,101
South Carolina	1,572	1,011	0	44	2,627
South Dakota	2,285	4,337	0	0	6,622
Tennessee	2,984	1,903	2,231	0	7,118
Texas	10,825	776	0	0	11,601
Virginia	1,423	1,542	118	0	3,083
Wisconsin	2,917	24,738	3,350	51	31,056
U.S. total	1,277,480	398,710	904,602	24,802	2,605,591
			Percent		
Percentage of total shipment volume	49.0	15.3	34.7	1.0	100.0

Note: States not having interstate shipments in 1977 are omitted.

1/ Shipments to port cities are included in these data. Exports to destinations outside the United States are not included. Exports by State are shown in table 10.

2/ This column reports sales by elevators to farmers located in other States. Not all States included farm sales in their questionnaire so these data are incomplete and underestimate total shipments to farmers.

Source: (17, p. 12).

Minnesota, and Missouri, where some were delivered to feed processors and others were reshipped to export points. Truck shipments from Illinois to out-of-State destinations totaled only 40 million bushels. Rates for moving grain over long distances by truck are higher than those for shipping it by rail or barge.

Barges carried 21.6 percent of the corn shipped across State lines; Illinois originated 58 percent of the total U.S. volume shipped by that mode. Nearly all corn shipped by barge, regardless of the State in which it originated, was destined for export.

The volume of corn received in each State from interstate shipments is shown in table 23. Port areas were the predominant destinations; half of the corn received in those areas arrived by rail and about half by barge. The large volume of rail and truck shipments received by Illinois firms indicates the State's importance as an assembly and reshipment point.

Movements to Ports

Table 24 shows the amount of corn that moved to port locations from each of the originating States by the various modes of transportation in 1977. The gulf region received the largest volume of corn, accounting for over a half of the total received by all ports. Most (77.6 percent) of this volume moved by barge from midwestern origins. Twenty-two percent of the corn shipped to the gulf ports went by rail, and Iowa, Illinois, Minnesota, and Nebraska were the most important origins for rail shipments to gulf ports. The amount of corn received by truck in the export regions is not a very significant factor in the total pattern, but truck transportation to ports is important in some States such as Alabama and Texas.

The Atlantic ports received 82 percent of shipments from Indiana and Ohio. Over 89 percent of the corn received by Atlantic ports moved by rail. Trucks also moved large volumes of corn from North and South Carolina to the Atlantic export region.

Trucks hauled 75 percent of corn shipments to ports along the Great Lakes from adjacent States. Trucks and railroads moved equal amounts of corn from Illinois origins; in Minnesota, truck shipments predominated. The Pacific export region received only 23.5 million bushels of corn in 1977, 77 percent from Nebraska. All but 429,000 bushels of that amount moved by rail. State shares of corn shipped to ports in 1977 are as follows:

State	Percentage of exports	State	Percentage of exports
Alabama	0.2	Nebraska	2.1
California	.3	New Jersey	.1
Delaware	.1	New York	.1
Florida	.1	North Carolina	1.2
Illinois	38.2	Ohio	11.1
Indiana	12.3	Pennsylvania	.1
Iowa	16.8	South Carolina	.3
Kansas	.3	South Dakota	.1
Kentucky	2.7	Tennessee	.1
Maryland	.5	Texas	.2
Michigan	3.6	Virginia	.3
Minnesota	6.1	Wisconsin	1.4
Missouri	1.8		

These data permit allocation of total exports to the States originating export shipments. Export shipments originate from a relatively small number of States, and the concentration is much greater than previous estimates have shown. For example, five States originated 84.5 percent of the total volume of corn received at all U.S. port regions. Illinois shipped 38.5 percent of corn received at all ports and 52.5 percent of the corn received at gulf ports. Iowa ranked second, accounting for 16.8 percent of the receipts at all ports and 22.8 percent of the gulf total. Indiana, which ranked third in the share of receipts at all ports (12.3 percent), accounted for 42.7 percent of the receipts at Atlantic ports followed by Ohio with 30.1 percent. Minnesota supplied 9.1 percent of corn shipments to the gulf ports and accounted for 6.1 percent of corn received at all U.S. ports in 1977. The estimated amount of corn received at all port areas in 1977 totaled 1.7 billion bushels. Almost 1.6 billion bushels that were inspected for export and the remainder of the receipts were either processed or reshipped to other U.S. destinations (table 25). In general, barges were the predominant mode of transportation; they carried more than two-thirds of the corn received at the ports in the gulf region. However, rail transportation at unit-train rates also moved large amounts of corn to ports, especially to Atlantic and Pacific ports.

The Changing Pattern of Domestic Flows

Previous surveys have been incomplete in terms of geographical coverage; therefore, it is not possible to evaluate fully changes in corn flow patterns over time. Market flow patterns

Table 23--Interstate shipments of corn received, by State and mode of transportation, 1977

Destination State	Mode of transportation				Total
	Rail	Truck	Barge	Farm truck 2/	
	1,000 bushels				
Alabama	52,692	8,112	32,210	0	93,014
Arizona	3,077	751	0	0	3,828
Arkansas	73,311	7,061	0	0	80,372
California	95,349	541	0	0	95,890
Colorado	35,853	2,851	0	0	38,704
Connecticut	9,395	0	0	0	9,395
Delaware	0	7,180	0	2,874	10,054
Florida	14,394	2,245	1,750	0	18,389
Georgia	73,044	2,043	0	806	75,893
Illinois	43,602	95,051	0	9,577	148,230
Indiana	4,059	14,614	0	22,183	40,856
Iowa	3,426	14,105	0	69	17,600
Kansas	23,066	18,298	0	3,402	44,766
Kentucky	3,693	5,667	0	14,000	23,360
Louisiana	170,251	2,890	860,485	0	1,033,626
Maine	13,354	0	0	0	13,354
Maryland	132,487	8,231	212	2,307	143,237
Massachusetts	440	0	0	0	440
Michigan	19	156	0	0	175
Minnesota	2,248	18,913	0	6,096	27,257
Mississippi	37,823	11,846	5,547	0	55,216
Missouri	26,132	18,858	0	0	44,990
Nebraska	963	7,601	0	3,081	11,645
Nevada	162	0	0	0	162
New Hampshire	164	30	0	0	194
New Jersey	377	367	0	0	744
New Mexico	636	0	0	0	636
New York	26,655	277	0	0	27,032
North Carolina	27,865	2,198	0	0	30,063
North Dakota	1,496	1,100	0	0	2,596
Ohio	0	47,282	0	22,110	69,392
Oklahoma	3,443	3,631	0	0	7,074
Oregon	7,151	77	0	0	7,228
Pennsylvania	46,096	10,599	0	2,862	59,557
South Carolina	15,836	1,604	0	91	17,531

See footnotes at end of table.

Continued--

Table 23--Interstate shipments of corn received, by State and mode of transportation, 1977 1/--Continued

Destination State	Mode of transportation				Total
	Rail	Truck	Barge	Farm truck 2/	
	1,000 bushels				
South Dakota	208	4,702	0	0	4,910
Tennessee	28,177	13,666	837	639	43,319
Texas	102,419	12,824	0	0	115,243
Utah	3,823	399	0	0	4,222
Vermont	4,176	236	0	166	4,578
Virginia	158,108	16,878	3,561	3,476	182,023
Washington	13,799	0	0	0	13,799
West Virginia	2,281	20	0	0	2,301
Wisconsin	15,430	35,578	0	1,360	52,368
Wyoming	500	128	0	0	628
U.S. total	1,277,480	398,710	904,602	95,099	2,675,891
	Percent				
Percentage of total	47.7	14.9	33.8	3.6	100.0

Note: States not having shipments to ports in 1977 are omitted.
1/ Receipts at port cities are included in the data for the respective State.
2/ This column shows elevator receipts in each State from farmers located in all other States as reported by elevators in the receiving States. Not all States included farm sales in their questionnaire so these data are incomplete and underestimate total receipts from farmers.

Source: (17, p. 13).

Table 24--Movements of corn to points of export, from originating State, by four modes of transportation, 1977 1/

Originating State or region	Export region	Mode of transportation				Total
		Rail	Truck	Barge	Farm truck	
		1,000 bushels				
Alabama	Gulf	0	1,061	2,381	100	3,542
California	Pacific	0	429	0	5,275	5,704
Delaware	Atlantic	0	90	1,307	0	1,397
Florida	Gulf	651	421	117	0	1,189
Georgia	Atlantic	0	215	0	0	215
Illinois	Atlantic	35,805	15	0	0	35,820
	Lake	2,645	23,668	3,665	95	30,073
	Gulf	85,113	403	500,711	0	586,227
Indiana	Atlantic	162,325	1,039	0	0	163,364
	Lake	0	28,335	0	628	28,963
	Gulf	4,658	0	15,790	0	20,448
Iowa	Lake	19,074	13,754	0	0	32,828
	Gulf	97,474	0	156,449	0	253,923
	Pacific	4,388	0	0	0	4,388
Kansas	Gulf	5,663	0	0	0	5,663
	Pacific	92	0	0	0	92
Kentucky	Gulf	2,503	0	44,266	0	46,769
Louisiana	Gulf	0	180	0	0	180
Maryland	Atlantic	0	6,605	71	1,949	8,625
Michigan	Atlantic	19,835	0	0	0	19,835
	Lake	0	29,243	0	5,015	34,258
Minnesota	Lake	4,504	621	0	0	5,125
	Gulf	25,508	0	75,594	0	101,102
Mississippi	Gulf	0	216	0	0	216
Missouri	Gulf	2,099	0	28,450	0	30,549
Nebraska	Gulf	17,910	0	1,825	0	19,735
	Pacific	16,773	0	0	0	16,773
New Jersey	Atlantic	0	2,159	0	0	2,159
New York	Atlantic	0	1,092	0	0	1,092
North Carolina	Atlantic	1,904	16,034	2,348	0	20,286
North Dakota	Lake	208	40	0	0	248
Ohio	Atlantic	114,147	963	0	0	115,110
	Lake	185	45,434	0	3,510	49,129
	Gulf	0	0	28,230	0	28,230
Oklahoma	Gulf	92	5	0	0	97
Pennsylvania	Atlantic	0	2,367	0	0	2,367
South Carolina	Atlantic	1,129	3,225	0	645	4,999
South Dakota	Lake	654	73	0	0	727
	Gulf	383	221	0	0	604
	Pacific	458	0	0	0	458
Tennessee	Gulf	0	0	2,231	0	2,231
Texas	Gulf	1,594	1,837	0	0	3,431

See footnotes at end of table

Continued--

Table 24--Movements of corn to points of export, from originating State, by four modes of transportation, 1977 1/--Continued

Originating State or region	Export region	Mode of transportation				Total
		Rail	Truck	Barge	Farm truck	
		1,000 bushels				
Virginia	Atlantic	0	0	1,611	3,623	5,234
Wisconsin	Lake	4,515	14,706	0	8,461	27,682
	Gulf	0	0	3,350	0	3,350
Ports-Lake	Ports-Lake	3,259	602	531	0	4,392
	Ports-Atlantic	2,202	0	0	0	2,202
	Ports-Gulf	1,496	0	6,814	0	8,310
Ports-Atlantic	Ports-Atlantic	0	95	0	0	95
U.S. total		639,246	195,148	875,741	29,301	1,739,436
		Percent				
Percentage of total		36.7	11.2	50.3	1.7	100.0

1/ Shipments between firms within a port area are excluded from these data. Shipments between port areas are shown separately from data for individual States of origin.

Source: (17, p. 14).

Table 25--Receipts of corn at port areas, by mode of transportation, 1977 1/

Port areas	Mode of transportation				Total	Inspections for export 3/
	Rail	Truck	Barge	Farm truck 2/		
	1,000 bushels					
Great Lakes Region:						
Duluth-Superior	5,428	758	0	0	6,186	5,526
Chicago	29,412	76,687	4,196	8,556	118,851	48,403
Toledo	185	75,455	0	9,153	84,793	84,933
Saginaw	19	3,576	0	0	3,595	3,576
Subtotal	35,044	156,476	4,196	17,709	213,425	142,438
Atlantic Region:						
North Atlantic	47,990	5,460	0	0	53,450	58,836
South Atlantic	289,357	28,439	5,337	6,217	329,350	299.087
Subtotal	337,347	33,899	5,337	6,217	382,800	357,923
Gulf Region:						
East Gulf	11,704	2,101	7,079	100	20,984	19,035
Louisiana Gulf	145,253	180	859,129	0	1,004,562	950,527
North Texas Gulf	87,657	1,938	0	0	89,595	91,766
South Texas Gulf	530	125	0	0	655	380
Subtotal	245,144	4,344	866,208	100	1,115,796	1,061,708
Pacific Region:						
Columbia River	2,883	0	0	0	2,883	0
Puget Sound	8,477	0	0	0	8,477	0
California	10,351	429	0	5,275	16,055	14,755
Subtotal	21,711	429	0	5,275	27,415	14,755
U.S. total	639,246	195,148	875,741	29,301	1,739,436	1,576,824
	Percent					
Percentage of total receipts	36.8	11.2	50.3	1.7	100.0	0

1/ Shipments between firms within a port area are excluded from these data.

2/ This column reports receipts at elevators in each port area delivered direct from farmers.

3/ Inspections for export conducted under the United States Grain Standards Act and reported in Grain Market News, Agricultural Marketing Service, U.S. Department of Agriculture, vol. 26, no. 2 (Jan. 13, 1978), p. 18.

Source: (17, p. 15).

constantly change as sellers attempt to take advantage of profitable marketing opportunities at a particular moment. Likewise, buyers continuously seek the most economical source of supply to meet current needs. The local supply and demand situation varies throughout the marketing year; consequently, changes in supply, demand, and transportation result in frequent changes in the most profitable shipping patterns.

Comparing flow patterns at different times can reveal trends in corn flow patterns. A survey of grain movements between the Corn Belt and South was conducted for 1970 by the SM-42 Regional Research Committee. Representatives from eight Southern States and three Corn Belt States participated in that survey, and the results emphasized the very special and important relationships among the areas represented by those States. The South is generally a deficit feed grain area with a large grain consuming animal industry, mainly different classes of poultry. While certain areas of the South may have surpluses of feed grains at harvest, the Southern States are net importers throughout most of the year.

The Corn Belt, on the other hand, is a surplus producing area and depends upon markets outside the local area. Corn Belt States have been moving an ever-increasing share of supplies to points of export in recent years. However, because of the relative closeness and existing transportation networks, the Corn Belt and the South have been and continue to be business partners in the feed grain/livestock economy. This special relationship makes it desirable to compare selected information from the 1970 survey with selected results from the 1977 survey to study changes in trade patterns (table 26).

Several factors have resulted in changes in corn trading between these two regions. First, corn production doubled in the 12 Southern States between 1969 and 1976, from 340 million bushels to 681 million bushels. This expansion exceeded the growth in corn feeding and feed grain shipments from midwestern origins to the South, which had declined by 27 percent. The proportion of these movements originating in the three eastern Corn Belt States increased slightly (76 percent in 1970, 80 percent in 1977). Second, corn production in the eastern Corn Belt increased 42 percent during these years, and marketing firms were forced to seek other markets, mainly exports. In 1970, 44 percent of interstate movements were to the South, 38 percent to export points, and 18 percent to other domestic destinations. In contrast, only 19 percent of interstate movements in 1977 headed for southern markets, 72 percent went to ports, and only 9 percent moved to other domestic points. This trend was most evident in Ohio, where the proportion of interstate shipments to port locations increased from 23 percent in 1970

Table 26--A comparison of 1970 and 1977 corn shipments from eastern Corn Belt origins to various destinations

Destination	Origin					
	Illinois		Indiana		Ohio	
	1970	1977	1970	1977	1970	1977
	Million bushels					
Intrastate	642.1	611.0	59.3	178.8	60.5	77.7
Interstate domestic:						
North Central States1/	51.0	26.6	38.8	67.1	11.4	3.1
Western States2/	3.6	1.5	0	.3	0	0
Northeast	2.5	2.7	13.5	17.0	32.4	18.8
Subtotal	57.1	30.8	52.3	84.4	43.8	21.9
Southern States:						
Alabama	66.3	39.0	8.8	24.6	1.1	2.6
Arkansas	0	7.3	0	0	0	0
Florida	8.9	2.5	1.8	6.9	3/	0
Georgia	45.2	27.5	22.2	30.9	1.1	5.0
Kentucky	2.9	1.2	30.0	4.4	9.3	2.5
Louisiana	13.1	22.6	0	0	0	0
Mississippi	40.3	31.1	11.8	4.3	0	.1
North Carolina	3/	2.6	.8	8.2	18.6	12.2
South Carolina	1.3	.1	3.5	.3	1.0	14.8
Tennessee	40.3	15.2	13.0	10.9	3.2	1.2
Virginia and West Virginia	0	0	.1	.9	26.6	1.9
Subtotal	218.3	149.1	92.0	91.4	60.9	40.3
Port for export	181.6	653.3	107.5	212.1	30.6	189.0
Total interstate	457.0	833.2	251.8	287.9	135.3	251.2

1/ Includes Corn Belt, Lake States, and Northern Plains regions.
2/ Includes Southern Plains, Mountain, and Pacific regions.
3/ Less than 50,000 bushels.

Source: (17, 33).

to 75 percent in 1977. Export destinations received 40 percent of Illinois interstate shipments in 1970 and 78 percent in 1977.

This trend has continued since 1977 as the volume moving in export channels jumped another 50 percent. These trends show that producers and marketing firms in the major corn producing States will become increasingly dependent upon the export market if the production potential of the U.S. corn industry is to be fully realized.

WORLD PRODUCTION AND TRADE

Although corn is native to America, it is cultivated for grain in most countries of the world and annually accounts for over one-fourth of total grain production. In 1979, world corn production reached a record 421 million metric tons and accounted for 27 percent of grain production. World wheat output reached an estimated 422 million metric tons that year, down from a record 447 million metric tons in 1978. World output of wheat and coarse grains soared to a record 1.2 billion metric tons in 1978, and average yields reached a record 2.1 metric tons per hectare (fig. 6). Although average corn yield and production hit record levels in 1979, total production of wheat and coarse grains declined 39 million metric tons.

World Supply and Distribution

Land area devoted to corn production around the world has increased gradually. About 127 million hectares of corn are now harvested for grain, a 27-percent increase since 1960 (table 27). Average yield per harvested hectare reached a record 3.35 metric tons in 1979/80, up 68 percent from 1960.

World consumption paralleled production, increasing from the previous year every year except three since 1960/61. Total world consumption, however, declined more than 30 million metric tons, and feed use dropped 27.5 million metric tons in 1974/75 following the drought-reduced crop and record low carryover stocks in the United States (table 27). Over 90 percent of this downward adjustment in feed use was made by livestock and poultry producers in the United States. U.S. feed use dropped by 24.9 million metric tons in 1974/75 (see fig. 3 and table 6). Thus, while the United States carries a disproportionate share of stocks when supplies are plentiful, U.S. livestock producers usually bear a disproportionate share of adjustment during years of tight world supplies.

Location of Production

The North American region continues to lead the world in annual corn production, accounting for about 50 percent of the world total (see tabulation). However, the North American region's share of the total has declined from about 56 percent in 1950 to about 52 percent in 1979. Asia is the second most

Region	Percentage of production	
	1950	1979
	Percent	
North and Central America	56.1	51.8
South America	6.4	7.2
Western Europe	2.8	5.4
Africa	7.5	6.1
Eastern Europe including USSR	10.2	10.4
Asia	16.9	19.0
Oceania	.1	.1

productive region, accounting for 19 percent of the world total in 1979; China produces about 70 percent of that region's corn.

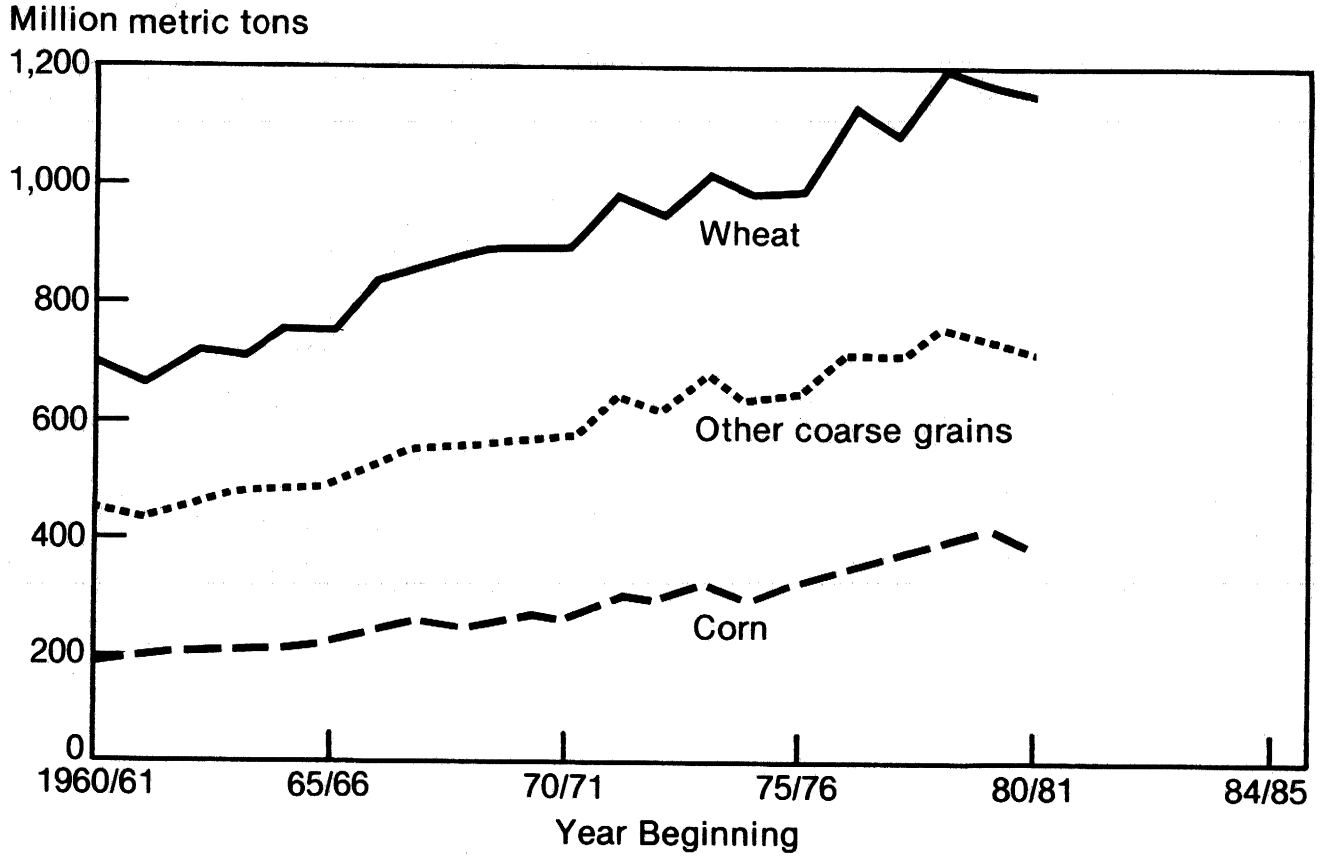
The annual production in each of the seven world regions since 1950 is shown in table 28. During the period, world production increased 207 percent, from 134 million metric tons in 1950 to 412 million metric tons in 1979. The North American region's share of the world total declined during the sixties because U.S. acreage was restricted. The North American region's share stood at only 45 percent of the world total in 1970 because of problems with the southern corn leaf blight, and in 1974, because of drought problems. In recent years, the United States has accounted for at least 90 percent of the region's production. In 1980, drought conditions adversely affected the North America region's output of corn, and world production dropped 8 percent.

The greater increase in production in other regions was due primarily to expansion in the area planted to corn. The United States, the North American region's leading producer, accounted for about 29 percent of the world area harvested for grain in 1960 but only 23 percent in 1979. Between 1960 and 1979, the area harvested for corn outside the United States increased 35 percent; in contrast, the area harvested for grain in the United States increased only 1 percent.

Average yields increased more in the North American region, and its production share declined less than its share of total area

Figure 6

Producing World Supplies of Coarse Grains and Wheat, 1960-80



Source: Foreign Agricultural Service, U.S. Department of Agriculture.

Table 27--World corn supply/distribution 1/

Year 2/	Area harvested	Yield per hectare	Stocks	Production	Imports	Exports	Consumption	
							Feed	Total
	1,000 hectares	Metric tons	1,000 metric tons					
1960/61	100,174	1.99	55,836	198,848	13,943	14,022	126,918	192,670
1961/62	101,467	2.00	61,809	202,956	20,024	20,125	133,743	211,154
1962/63	101,560	2.03	53,510	205,925	20,155	20,050	135,953	213,704
1963/64	104,413	2.08	45,874	216,727	21,880	21,826	133,955	211,985
1964/65	103,177	2.07	50,634	214,023	24,419	23,946	136,907	223,411
1965/66	101,522	2.22	41,717	225,018	28,009	28,073	145,364	233,372
1966/67	106,228	2.32	33,299	246,568	27,250	27,011	150,141	242,629
1967/68	107,642	2.41	37,477	259,399	29,274	29,207	157,661	252,642
1968/69	106,423	2.35	44,301	250,488	28,432	26,951	161,861	255,391
1969/70	107,401	2.49	40,879	267,203	31,780	31,162	170,168	270,345
1970/71	110,170	2.39	38,355	263,378	31,938	32,079	164,881	270,570
1971/72	113,080	2.66	31,106	300,410	35,310	35,535	184,986	289,374
1972/73	108,489	2.72	41,833	294,606	44,715	44,597	199,657	305,873
1973/74	115,998	2.77	30,083	321,551	54,172	54,211	207,276	324,478
1974/75	116,599	2.49	27,153	290,307	46,491	46,802	179,735	293,870
1975/76	119,351	2.75	23,295	327,660	61,078	60,694	203,580	326,107
1976/77	123,254	2.88	25,484	354,831	59,439	60,905	201,557	339,628
1977/78	124,052	2.94	39,047	264,690	68,014	66,404	217,392	359,534
1978/79	125,239	3.12	45,813	390,551	69,112	70,969	236,651	386,305
1979/80	125,611	3.35	48,037	420,994	78,350	78,525	257,201	411,661
1980/81	127,384	3.03	57,195	386,080	79,476	84,039	253,776	408,643

1/ Data on stocks, imports, exports, and consumption are based on an aggregate of differing local marketing years. Thus, stocks data should not be construed as representing world stock level at a fixed time. Also, data on production, imports, and exports differ from totals reported in tables 28, 29, and 30.

2/ World production year beginning July 1.

Source: (49).

Table 28--Annual corn production, by world region

Calendar year	North & Central America	South America	Africa	Asia	Oceania	Eastern Europe	Western Europe	World
				Million metric tons				
1950	75.3	8.5	10.1	22.6	0.2	13.6	3.7	134.0
1951	72.3	11.1	10.3	24.2	.1	15.7	4.9	138.6
1952	81.1	10.1	9.9	25.8	.1	11.0	4.4	142.4
1953	79.1	11.7	11.8	25.9	.1	15.0	5.6	149.1
1954	75.3	75.3	12.4	27.5	.1	15.7	5.5	149.9
1955	79.8	11.3	12.4	29.7	.1	26.5	5.8	165.6
1956	84.7	13.0	12.4	33.7	.1	20.9	6.8	171.7
1957	84.1	12.6	13.2	32.3	.1	22.1	6.5	170.9
1958	92.8	14.6	13.0	35.5	.2	22.2	7.1	185.3
1959	105.1	15.0	13.6	27.2	.2	23.8	7.6	192.6
1960	107.1	15.2	13.9	25.9	.2	27.3	8.6	198.1
1961	100.0	16.4	15.0	30.2	.2	32.2	8.6	202.5
1962	100.6	17.4	16.4	34.4	.2	31.1	7.1	207.1
1963	111.7	17.3	16.7	34.7	.2	28.6	9.8	219.0
1964	100.1	17.6	15.1	37.6	.2	33.7	8.4	212.6
1965	116.5	20.1	15.8	38.1	.2	25.2	8.9	224.7
1966	118.7	21.4	17.9	40.7	.1	31.3	10.3	240.4
1967	135.6	24.5	22.3	44.2	.2	29.4	10.6	266.9
1968	126.2	22.4	17.9	42.3	.2	29.0	12.4	250.5
1969	131.4	22.6	18.6	42.4	.2	35.4	13.9	264.2
1970	119.0	26.9	18.5	48.3	.2	30.1	16.4	259.5
1971	157.7	27.4	21.8	44.8	.3	31.9	18.0	201.8
1972	154.2	23.8	23.5	42.2	.3	37.0	17.9	298.7
1973	157.4	26.2	17.2	47.2	.2	38.3	20.7	307.1
1974	131.0	28.1	26.1	51.2	.2	36.3	18.3	291.1
1975	161.2	26.0	24.2	53.9	.3	36.9	18.1	320.6
1976	174.6	30.4	24.3	56.6	.4	40.0	15.0	341.3
1977	177.8	27.2	24.2	54.2	.4	41.0	19.7	344.5
1978	196.8	28.8	23.8	78.9	.4	36.7	20.6	386.0
1979	213.9	29.5	25.0	78.5	.3	42.9	22.3	412.4
1980	182.4	33.0	25.1	79.7	.4	36.9	21.8	379.2

Sources: (31, 49).

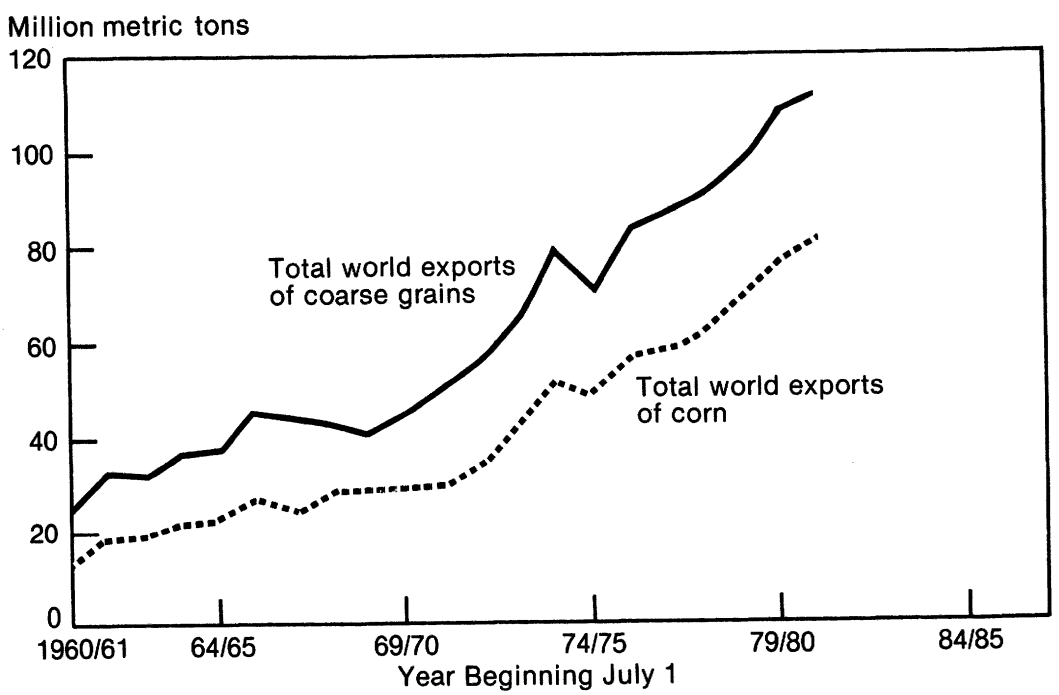
harvested. Average yields per hectare in the North American region increased 159 percent from 2.11 metric tons in 1950 to 5.47 metric tons in 1979. Average yields per hectare in all other regions combined increased 105 percent from 1.1 metric tons in 1950 to 2.25 metric tons in 1979. Worldwide average corn yield was 3.24 metric tons per hectare in 1979.

World Trade

World trade in coarse grains (all grains except wheat and rice) has increased 360 percent since 1960/61 and stood at a record 112 million metric tons in 1980/81. This rapid expansion in trade reflects a growing demand for feed grains as many nations are increasing livestock and poultry production. Corn has become the underpinning of the international trade in feed grains, and it currently accounts for about 75 percent of the international trade in coarse grains, up from about one-half in 1960/61 (fig. 7).

Figure 7

Exporting Corn and Coarse Grains on the World Market, 1960-80



Source: Foreign Agricultural Service, U.S. Department of Agriculture.

Exports

World trade in corn more than doubled in the seventies, and this international market is supplied by a small number of exporting countries. The United States and two Southern Hemisphere exporters--Argentina and South Africa--account for approximately 90 percent of the annual total. The United States alone generally supplies about 80 percent of exports.

Exports for selected exporting countries or regions are presented in table 29. Exports from the United States showed a fivefold increase during the seventies while exports from other origins remained fairly stable. Argentina is the second largest corn exporter in the world. That country's share of the market has declined from almost 20 percent in 1966/67 to about 7 percent in 1980/81. Argentine exports ranged from 2.6 to 6.6 million metric tons during the seventies. Argentine exports dropped in 1979/80 following a drought-reduced crop of 6.4 million tons. Exports from that country are expected to bounce back in 1980/81.

Exports from South Africa have fluctuated greatly, and ranged from 0.3 to 3.3 million metric tons during the seventies; exports are expected to reach a record 3.5 million metric tons in 1980/81. Exports from Western Europe were very stable during the seventies, peaking at 6.4 million metric tons in 1973/74. Much of this volume was traded among members of the European Community (EC); however, the USSR purchased sizable quantities from Western Europe following the partial suspension of U.S. shipments.

Imports

In contrast to the small number of exporters, the demand for corn is dispersed throughout the world. In 1979/80, 101 nations imported 1,000 metric tons or more (49, June 5, 1981, pp. 14-15), and Japan was the leading importer, accounting for 15 percent of the world total. Imports have followed the same trend as exports since 1950 (table 30). Reported exports (table 29) usually exceed reported imports (table 30) because of under-reporting, handling losses, and the fact that imports in many countries are estimated on the basis of secondary data sources.

The Changing Markets for U.S. Corn

The United States exports corn to 95 nations. During the seventies, the EC, Japan, and the USSR were the largest customers. These three destinations accounted for over 60 percent of U.S. corn exports prior to 1978/79. Shipments to these destinations for 1971-80 are shown in table 31.

Purchases of U.S. corn by the EC are greatly affected by the Common Market's variable levy system, whereby all corn imported is subject to an import levy that brings the price up to almost $5 per bushel. When corn prices increase (decrease), the levy is reduced (increased) to maintain a nearly stable price

Table 29--World corn exports

Fiscal year beginning July 1	United States	Argentina	South Africa	Western Europe	Other	World
			1,000 metric tons			
1950/51	2,089	158	60	51	2,313	4,671
1951/52	2,043	611	216	90	1,826	4,786
1952/53	3,124	636	48	33	902	4,752
1953/54	2,756	1,315	328	19	1,130	5,548
1954/55	1,947	1,738	580	115	1,831	6,211
1955/56	3,042	428	916	157	1,843	6,386
1956/57	3,554	1,092	1,131	85	1,219	7,081
1957/58	4,625	1,022	1,280	44	2,004	8,975
1958/59	5,169	2,108	870	86	1,682	9,915
1959/60	5,502	3,170	912	230	2,404	11,718
1960/61	6,326	1,897	1,041	773	2,825	12,862
1961/62	9,922	2,253	1,820	477	3,900	18,732
1962/63	10,195	2,723	2,694	606	3,519	19,737
1963/64	11,558	2,452	2,580	1,330	4,413	22,333
1964/65	13,080	3,442	892	1,493	4,499	23,406
1965/66	16,988	2,923	426	1,926	5,004	27,330
1966/67	12,548	5,082	824	2,236	5,158	25,848
1967/68	14,516	3,186	3,107	1,731	5,635	28,175
1968/69	12,979	3,968	2,168	2,998	5,888	28,001
1969/70	15,873	4,346	1,096	3,135	4,117	28,561
1970/71	13,078	5,333	915	4,637	5,882	29,845
1971/72	16,719	4,801	2,829	4,787	4,274	33,410
1972/73	28,892	2,832	3,181	4,210	4,833	43,948
1973/74	34,853	5,105	371	6,400	8,132	54,861
1974/75	28,384	5,831	3,324	5,114	8,729	51,382
1975/76	39,590	2,595	1,353	5,718	11,290	60,546
1976/77	42,348	4,384	1,366	4,741	5,537	58,376
1977/78	45,085	5,995	2,697	4,371	4,582	62,730
1978/79	51,246	6,664	2,722	4,700	4,218	69,550
1979/80	62,115	4,063	2,689	4,607	4,422	77,896
1980/81 1/	64,702	5,837	3,500	4,453	4,049	82,541

1/ Preliminary.

Source: (49).

Table 30--World corn imports 1/

Fiscal year beginning July 1	Western Europe	Japan	USSR and Eastern Europe	Other	World
			1,000 metric tons		
1950/51	3,867	50	321	1,055	5,293
1951/52	4,086	17	230	789	5,122
1952/53	3,193	102	430	683	4,408
1953/54	4,096	210	367	1,033	5,706
1954/55	4,583	315	547	444	5,889
1955/56	4,682	270	836	559	6,347
1956/57	5,038	466	209	1,109	6,822
1957/58	5,406	565	668	1,938	8,577
1958/59	7,020	855	605	1,466	9,946
1959/60	8,790	1,018	602	1,336	11,746
1960/61	8,983	1,708	695	1,582	12,968
1961/62	11,275	2,109	1,265	2,838	17,487
1962/63	13,113	2,396	926	3,169	19,604
1963/64	15,100	3,076	1,504	3,238	22,918
1964/65	14,684	3,223	1,250	2,530	21,687
1965/66	18,763	2,887	1,207	2,956	25,813
1966/67	18,407	3,837	873	2,588	25,705
1967/68	18,943	4,582	1,433	3,314	28,272
1968/69	17,637	5,287	1,642	3,271	27,837
1969/70	17,278	5,975	844	4,330	28,439
1970/71	18,071	5,173	1,728	4,203	29,175
1971/72	19,144	5,416	3,526	3,919	32,005
1972/73	20,435	6,881	6,916	7,558	41,790
1973/74	24,859	8,210	6,654	10,348	50,071
1974/75	24,957	7,388	6,082	9,119	47,546
1975/76	22,578	7,879	16,266	8,345	55,068
1976/77	29,133	8,874	10,018	10,053	58,078
1977/78	24,156	9,717	15,130	11,979	60,982
1978/79	24,590	10,936	14,636	18,472	68,634
1979/80	23,823	11,876	22,859	20,328	78,886
1980/81 2/	23,793	13,900	18,025	23,787	79,505

1/ The total volume exported each year (table 29) is not totally accounted for in reports from importing countries. Consequently, total exports in a particular fiscal year usually exceed total imports.

2/ Preliminary.

Source: (49).

Table 31--U.S. corn exports (grain only) to selected destinations

Year beginning Oct. 1	Destination				Total
	EC-9	Japan	USSR	Other	
	Million bushels				
1971/72	319	111	136	220	786
1972/73	432	252	132	426	1,242
1973/74	394	251	129	452	1,226
1974/75	418	206	40	461	1,125
1975/76	525	228	414	532	1,699
1976/77	687	301	115	656	1,668
1977/78	438	338	412	742	1,930
1978/79	451	360	446	877	2,134
1979/80	527	446	231	1,201	2,405

Source: (49).

within the market, resulting in a constant corn price for livestock producers. EC imports are very insensitive to changes in U.S. export prices; EC import levels depend mainly on the size of their grain crops and livestock numbers.

Japan imports all the feed grains used in its livestock industry, and virtually all of that supply comes from the United States. Japan was a growing market for U.S. corn during the seventies when U.S. corn exports to that country increased fourfold. Unlike the EC, Japan has no important restrictions on corn imports so the quantities imported showed some responses to changes in U.S. export prices.

The USSR became a major market for U.S. corn during the seventies. USSR import requirements depend mainly on domestic grain production which is subject to large variations due to the variable climate. USSR corn imports from the United States reflected this variability during the seventies when shipments ranged from 40 million bushels in 1974/75 to 446 million

bushels in 1978/79. Since 1972/73, large changes in U.S. exports of corn have reflected sizable changes in shipments to the USSR.

The reduction in shipments to the USSR in 1979/80 were more than offset by a sizable increase in exports to China, Mexico, Poland, Portugal, Spain, and Taiwan (see table 20 for export destinations in 1978/79 and 1979/80).

The EC is becoming more self-sufficient in grain production. Although corn imports are sizable, those countries, as a group, are exporting large quantities of wheat as well, and are becoming major competitors in the world wheat market. The greatest market potential for U.S. corn appears to be in East Asia, where imports of grain are increasing rapidly, and in Mexico where future imports may rise significantly.

THE CORN PRICING SYSTEM

Price at a particular moment reflects the expected supply and demand conditions for the crop year and the traders' collective judgment of the price level necessary to allocate inventories over time. Price directs the use of production resources among competing farm enterprises and determines the income derived from the ownership of these resources.

The interaction of supply and demand determines the overall price level for corn. The price level is discovered through the interactions of buyers and sellers on organized grain exchanges. Actual supply and demand for corn and the resulting price is difficult to assess since corn is produced and consumed throughout the world. During the month preceding harvest, and as harvest progresses, traders are constantly estimating crop size. Each new appraisal is generally accompanied by a temporary price fluctuation.

Once harvest is completed and supply is known with reasonable certainty, changes in traders' evaluations of demand prospects for the remainder of the year become the most important determinants of price. As new information on demand prospects becomes available, traders change their judgment of what prices are likely to be and trade accordingly. For a seasonally produced commodity like corn, the lowest price usually occurs at harvest, and prices generally rise during the year by an amount sufficient to cover storage and other carrying charges.

Organized Grain Exchanges

Organized grain exchanges or boards of trade are important to pricing corn. The primary U.S. market for trading corn is the Chicago Board of Trade where the bulk of trading in corn futures contracts occurs (6). A futures contract specifies a standard grade of the commodity which must be delivered in

fulfillment of the contract at some future date. In addition, spot or cash trading in corn is done on that market and several other organized exchanges in the country. Cash trading involves actual trades in the commodity and is based on a sample and official grade certificate for each carlot. Generally, the current futures price established for a delivery month is used as the base for establishing the cash price paid for specific lots of the commodity.

The primary aim of an organized exchange such as the Chicago Board of Trade is to provide and regulate a marketplace so that its members have facilities for trading in futures contracts. These members represent trade interests and brokerage firms, which provide market access to the general public. A major advantage of an organized exchange is that it provides an impersonal and regulated method of price discovery which is not subject to the control of buyers and sellers. Consequently, they perform the important function of discovering, not determining prices that will equate demand and supply in the short run and allocate inventories over time (see 16 for additional information).

Futures Trading

All futures contracts for corn are the same except for the month of delivery and exchange price. Trade is based on standard 5,000-bushel contracts and all other terms including the quality, method of payment, and place of delivery are standardized. The delivery months for corn futures contracts are December, March, May, July, and September. Contracts are bought and sold in a personal, face-to-face, open-outcry auction. Each trader attempts to gauge the price in the delivery month on the basis of knowledge of supply and demand conditions. If the current futures price for the delivery month is higher than the expected price, the trader sells a quantity of this future, intending to make an offsetting purchase after the price has come down in line with expectations. If the current futures price is lower than the trader's expected price at a later date, the trader then buys the contract, intending to sell a corresponding amount later. If prices move according to the trader's expectations, there is a profit, which represents a loss to other traders whose price expectations were different, establishing an opposing position in the market.

There is only one buyer and one seller for every contract sold. When a transaction occurs, one makes money and the other loses by the same amount. The exchanges themselves do not trade, but cover operating costs by charging a commission on each trade. Each exchange has a limited number of seats or memberships, which may be purchased only by private individuals who meet the exchange's financial and moral requirements. However,

these individuals may be sponsored by other persons, companies, or corporations who have greater finanacial assets. Seat holders are not required to trade but all trading must be done through them.

Cash Trading

Cash or spot trading is an alternative to futures. In markets where both cash and futures trading take place, the nearby (closest trading month) futures price serves as the base for discovering the cash prices paid for specific lots of commodities. Spot prices are generally quoted in terms of a basis over or under the nearby futures. The basis quote usually represents U.S. No. 2 Yellow corn, and buyers and sellers negotiate cash premiums or discounts based on actual grade as determined under the U.S. grading standards (see table 16).

In organized grain exchanges, where futures contracts are not traded, the current price of nearby Chicago futures contracts is often used as a reference for establishing cash prices. Additional discounts and premiums reflect differences in location, a practice called basis pricing. For example, a buyer might bid "15 cents off the March," to a country shipper, meaning a payment of 15 cents per bushel less than the price quoted for the March futures contract on the Chicago Board of Trade whenever the country shipper wants to sell. Within a trading day, the basis normally holds relatively constant even though the futures and cash prices show substantial fluctuations. This pricing procedure enables market participants to determine the current cash bid price any time during the day by simply applying the basis to the latest futures price quotation for the specified delivery month.

Another form of pricing cash grain is to specify price in terms of the basis, a practice commonly called booking the basis. By mutual agreement, the buyer or seller is allowed a specified period of time to choose a date when the cash price for the transaction is determined by applying the agreed upon basis to the then current futures quotation. Booking the basis sets the delivery terms and fixes the price relative to a specific futures price, but it leaves both buyer and seller exposed to price level risk. This risk is frequently reduced by hedging in the futures market or by cash-forward contracting by one or both parties.

A recent survey of the grain trade was made on the use of basis pricing by grain firms for specifying price in corn sales agreements (15). The percentage of elevators by type that used the basis for quoting price in sales agreements during 1974 are shown as follows:

Frequency of use	Country elevators	Terminal and sub-terminal elevators
	Percent	
Never	38.4	15.5
50 percent or less	33.2	18.5
More than 50 percent	28.4	66.0
Total	100.0	100.0

Basis pricing was used more extensively by terminal and sub-terminal elevators in comparison to country elevators. The survey revealed that over 95 percent of the terminal group in some States were quoting prices in terms of the basis in more than 50 percent of their sales agreements.

Prices Over Space and Time

Many prices are quoted for corn at any point during the marketing season. The various individual prices are functionally related and together form the equilibrium price level for corn that exists at a particular point. The many prices of corn can best be illustrated with the following example--on April 9, 1981, the following prices were quoted for No. 2 Yellow corn (51):

Markets	Apr. 9, 1981	Apr. 10, 1980	Change
		Dollars/bushel	
Cash quotation:			
Chicago	3.56½	2.63½	0.93
Kansas City	3.43½	2.51½	.92
Memphis	3.83½	2.80	1.03½
Minneapolis	3.32¼	2.37½-2.39½	.93-3/4
Omaha	3.21½-3.26½	2.32 -2.32½	.91-3/4
St. Louis	3.50 -3.51	2.50 -2.54	.98½
Toledo	3.35½-3.41	2.53½-2.57½	.83¼
Chicago futures:			
May delivery	3.70½	2.70½	1.00
July delivery	3.82¼	2.82½	.99¼
Sept. delivery	3.90½	2.92	.98½
Dec. delivery	3.95½	2.97¼	.98¼

These quotations illustrate the time and space dimensions of the corn pricing system. The time dimension involves the past (current prices compared to the previous year's prices) and the future (future contracts for delivery later in the marketing year). The futures for December delivery reflects traders' current evaluations of supply and demand prospects for the next marketing year.

The changes in the prices that occurred between the 2 crop years at various locations illustrate the rather stable spatial relationships that exist among the prices. For example, the change in cash prices at Chicago, Kansas City, Minneapolis, and Omaha, between the two dates, ranged from 0.91-3/4 to 0.93-3/4 cents. The basis widened in April 1981 compared to April 1980. For example, on Apr. 10, 1980, corn traded at 19 cents per bushel under May in Kansas City, and on Apr. 9, 1981, corn traded at 27 cents per bushel under May. The basis usually widens at higher price levels because merchandisers feel that greater risks exist.

Prices Over Space

The market performance of pricing corn over space is considered highly efficient. Movement of corn from one area to another is triggered when the price difference between the two areas exceeds the transportation and handling cost plus a small profit margin. All local spot prices are derived from the central price and the corresponding differences in the above costs. Spatial differentials constantly change in response to changes in local supply and demand conditions and to changes in transportation rates. Prices at selected markets during 1950-79 are shown in table 32.

Year-to-year changes in price differentials among markets are minor and reflect changes in local supplies of corn. Shifts in production and consumption and changes in transportation rates occur more slowly and result in noticeable changes in differentials over time. For example, the difference in prices at Omaha and Stockton increased rapidly during the late seventies, reflecting the rapid increases in rail rates and the increased dependence of California livestock feeders on imports of feed grains from the Plains States. The differential between Omaha and other markets such as St. Louis has increased in recent years. This differential reflects the relative transportation disadvantages of Omaha grain firms in supplying the large export demand that is focused on gulf ports.

Prices Over Time

Pricing of corn over time is a highly speculative activity. The current spot prices at various locations show a consensus that this price and no other will efficiently allocate the total supply of corn so that the last of the old crop is concurrently consumed with the arrival of the new crop. Each

Table 32--Corn average price per bushel, selected grades and markets, and season average price received by farmers1/

Year beginning Oct. 1	No. 2 Yellow						No. 3 White, Kansas City	Season average farm price
	Chicago	Kansas City	Minne-apolis	Omaha	St. Louis	Stockton		
	Dollars							
1950/51	1.73	1.61	1.60	1.59	1.70	2.04	1.84	1.52
1951/52	1.83	1.82	1.73	1.77	1.85	2.26	2.10	1.66
1952/53	1.59	1.58	1.49	1.53	1.63	2.03	2.09	1.52
1953/54	1.53	1.55	1.43	1.46	1.55	1.98	1.72	1.48
1954/55	1.48	1.52	1.38	1.46	1.51	1.93	1.50	1.43
1955/56	1.24	1.41	1.24	1.38	1.37	1.85	1.47	1.35
1956/57	1.31	1.30	1.23	1.30	1.33	1.68	1.56	1.29
1957/58	1.21	1.18	1.05	1.12	1.34	1.57	1.75	1.11
1958/59	1.21	1.14	1.08	1.09	1.23	1.54	1.25	1.12
1959/60	1.17	1.10	1.03	1.07	1.17	1.52	1.15	1.05
1960/61	1.10	1.05	.99	1.01	1.14	1.48	1.23	1.00
1961/62	1.11	1.10	1.02	1.03	1.15	1.50	1.48	1.10
1962/63	1.19	1.20	1.11	1.13	1.26	2/1.54	1.22	1.12
1963/64	1.20	1.23	1.13	1.17	1.28	1.58	1.32	1.11
1964/65	1.26	1.30	1.20	1.26	1.34	1.61	1.55	1.17
1965/66	1.27	1.27	1.22	1.23	1.37	1.58	1.37	1.16
1966/67	1.36	1.37	1.29	1.30	1.41	1.60	1.49	1.24
1967/68	1.12	1.18	1.09	1.12	1.16	1.46	1.21	1.03
1968/69	1.17	1.17	1.14	1.16	1.23	1.55	1.63	1.08
1969/70	1.25	1.27	1.16	1.21	1.33	1.60	1.75	1.16
1970/71	1.47	1.45	1.35	1.39	1.45	1.73	1.94	1.33
1971/72	1.23	1.27	1.15	1.23	1.19	1.66	1.26	1.08
1972/73	1.91	1.93	1.71	1.80	1.87	2.39	2.48	1.57
1973/74	2.95	2.91	2.78	2.79	2.87	3.43	3.66	2.55
1974/75	3.12	3.08	3.05	3.05	3.07	3.66	4.09	3.03
1975/76	2.75	2.69	2.67	2.66	2.70	3.34	2.92	2.54
1976/77	2.30	2.26	2.25	2.15	2.25	2.85	2.91	2.15
1977/78	2.26	2.28	2.13	2.08	2.23	2.89	3.30	2.02
1978/79	2.54	2.56	2.32	2.28	2.51	3.23	2.93	2.25
1979/80	2.81	2.72	2.53	2.49	2.73	3.54	4.70	2.52

1/ Average of bulk-of-sale price for a day each week from 1950-69. Beginning in 1970, data are simple averages of daily cash prices.
2/ Prior to 1962, prices were quoted at San Francisco.

Sources: (43, 44, 46, 51).

day, new and updated information flows into the exchanges, different opinions are formed by traders, and changes in the price level occur. Most traders have a realistic view of the current supply and demand situation based on personal interpretations of available data. However, current prices also reflect future expectations of world supply (domestic supply is essentially fixed) and demand since corn will be bought and stored if prices are expected to go up, and conversely, corn will be sold for future delivery if lower prices are expected.

Seasonal average prices received by farmers were relatively high in the early fifties because of high price support rates. Support prices were the major determinant of farm price in the fifties and sixties. Prices received by farmers remained close to the loan rate until 1972 when prices began to respond to the increasing world demand for corn. Between 1971 and 1974, the average price received by farmers increased rapidly. Farm prices trended downward through 1977 but have rebounded in response to increases in demand and the drought problems of 1980.

Price Relationships

The price levels and spreads for No. 2 Yellow corn at Chicago and the prices received by farmers are shown on an average quarterly basis in table 33. Prices were relatively stable during the 1970/71 and 1971/72 marketing seasons. During this period, farm prices averaged $1.23 per bushel and cash prices at Chicago averaged $1.36 per bushel. The farm/market price spread during this period ranged from 11 to 15 cents. The USSR began purchasing large quantities of U.S. corn in 1972/73, and the average cash price in Chicago increased to $2.58 during the June-September quarter, an increase of 97 percent over the same quarter of the previous year. The average farm price increased less dramatically, and the average price spread rose to 37 cents during the final quarter of 1972/73. The price spread averaged 30 cents during 1973/74 as farm/market prices continued to increase.

Average farm/market prices reached record levels in the fall of 1974, followed by 3 years of declining prices. Between the fall of 1974 and the summer of 1977, farm/market prices declined about 45 percent. The average price spread was very stable and averaged 20 cents. Farm/market prices resumed an upward trend with a substantial amount of seasonal variation during the 1977-79 marketing seasons. The average quarterly price spread ranged from 16 to 35 cents during this period and averaged 25 cents.

These price relationships suggest that price changes at the farm level generally lag price changes at central markets (fig. 8). The relationship between farm and market prices is

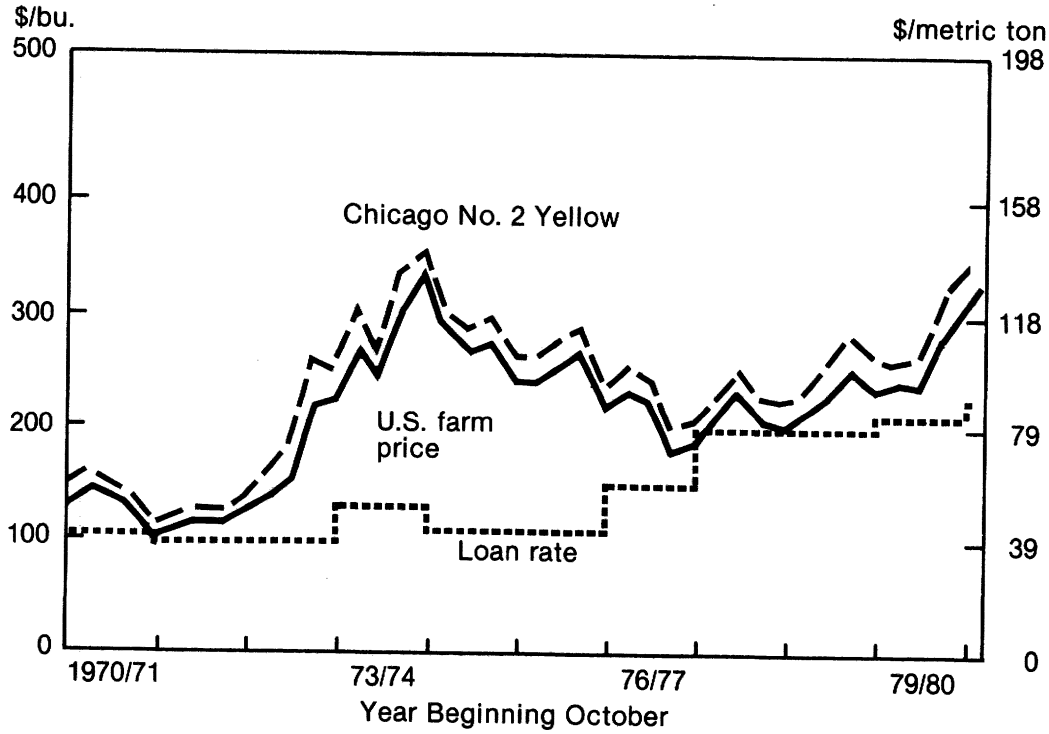
Table 33--Quarterly farm/market price relationships for corn

Marketing year beginning Oct. 1	Average price received by farmers	Average daily price at Chicago	Average price spread	Marketing year beginning Oct. 1	Average price received by farmers	Average daily price at Chicago	Average price spread
	Dollars/bushel				Dollars/bushel		
1970/71:				1975/76:			
Oct.-Dec.	1.33	1.47	0.14	Oct.-Dec.	2.44	2.64	0.20
Jan.-Mar.	1.43	1.57	.14	Jan.-Mar.	2.47	2.67	.20
Apr.-May	1.40	1.52	.12	Apr.-May	2.54	2.83	.29
June-Sept.	1.27	1.38	.11	June-Sept.	2.70	2.89	.19
1971/72:				1976/77:			
Oct.-Dec.	1.03	1.14	.11	Oct.-Dec.	2.20	2.42	.22
Jan.-Mar.	1.09	1.22	.13	Jan.-Mar.	2.34	2.53	.19
Apr.-May	1.14	1.28	.14	Apr.-May	2.28	2.46	.18
June-Sept.	1.16	1.31	.15	June-Sept.	1.80	1.98	.18
1972/73:				1977/78:			
Oct.-Dec.	1.27	1.41	.14	Oct.-Dec.	1.84	2.06	.22
Jan.-Mar.	1.37	1.59	.22	Jan.-Mar.	2.09	2.25	.16
Apr.-May	1.52	1.83	.31	Apr.-May	2.27	2.54	.27
June-Sept.	2.21	2.58	.37	June-Sept.	2.09	2.27	.18
1973/74:				1978/79:			
Oct.-Dec.	2.25	2.52	.27	Oct.-Dec.	2.03	2.26	.23
Jan.-Mar.	2.68	3.01	.33	Jan.-Mar.	2.17	2.35	.18
Apr.-May	2.44	2.70	.26	Apr.-May	2.31	2.60	.29
June-Sept.	3.04	3.37	.33	June-Sept.	2.54	2.86	.32
1974/75:				1979/80:			
Oct.-Dec.	3.35	3.56	.21	Oct.-Dec.	2.35	2.67	.32
Jan.-Mar.	2.87	3.02	.15	Jan.-Mar.	2.41	2.60	.19
Apr.-May	2.67	2.89	.22	Apr.-May	2.39	2.66	.27
June-Sept.	2.78	2.99	.21	June-Sept.	2.79	3.14	.35

Source: (43).

Figure 8

Corn Prices and Loan Rates, By Quarter, 1970-79



much more stable in periods of stable or declining prices. Periods of increasing prices seem to involve greater price uncertainty, and as a consequence, the average price spread tends to widen. The drought of 1980 reduced crop prospects, and market prices increased 18 percent during the summer quarter. This price increase was accompanied by an 8-cent increase in the price spread. The price spread increased to 36 cents as farm/market prices continued to advance during the fall of 1980.

The average price received by farmers exceeded the price support rate established under Government feed grain programs throughout the seventies except during the fall of 1971 and the fall of 1977. Government programs substantially influenced the corn subsector throughout the study period.

COSTS

Costs are associated with production, drying, handling, storing, transporting, and processing. Costs at each step of the corn production and marketing process are affected by inflation, firm size or volume, and competition. Costs increased substantially during the late seventies, a period of high rates of inflation.

Production

Data related to the cost of production are available from several sources. Congress in the Agriculture and Consumer Protection Act of 1973 (Public Law 93-86) directed the Secretary of Agriculture to conduct a cost-of-production study for major crops grown in the United States. In response to that directive, the U.S. Department of Agriculture (USDA) surveyed over 4,000 producers in 1975 to collect cost data for the 1974 crop. The survey was repeated in 1979 to collect data for the 1978 crop. Regional estimates of production cost in 1979 were developed from the more recent survey data (table 34). Total cost per acre (excluding land) varied from a low of $173 in the Corn Belt-Lake States to a high of $234 in the Southwest and the weighted average for all regions was $178. The higher costs in the Southwest reflected the greater requirements for labor, fuel, and machinery associated with irrigation.

Cost per bushel (excluding land) averaged $1.62 and ranged from a low of $1.49 in the Corn Belt and Lake States to a high of $2.26 in the Southeast (table 35). The lower cost estimates for the Corn Belt and Lake States mark the record yields of 1979 (116.0 bushels per acre); those regions accounted for about 70 percent of U.S. production in 1979. The yield potential is reflected in the higher land values in that region. The cost allocation to land was 60 cents when based on average acquisition value, and $1.09 when based on current value.

Using current land values, total costs per bushel for the owner-operator operation ranged from $2.49 in the Northern Plains to $3.09 in the Southeast and averaged $2.60 for all regions. The average per bushel cost for a cash renter was $2.17 while the average cost for share renters was $2.42 per bushel.

Estimates of the costs per acre and per bushel for 1975-80 are presented in table 36. Total costs per acre (excluding land) increased from $134 in 1976 to a preliminary estimate of $214 in 1980, an increase of 60 percent in 5 years. Between 1975 and 1979, average yield per acre increased as rapidly as production costs per acre; therefore, costs per bushel changed very little. In contrast, average yield dropped to 91 bushels per acre in 1980, and the costs per bushel rose sharply. Thus, producers are very vulnerable to adverse climatic conditions that can have tremendous impacts on corn yields and per bushel costs.

The regional estimates of production costs were based, in part, on supplemental cost data contained in USDA's Firm Enterprise Data System (FEDS), a system that consists of a series of computerized crop enterprise budgets serviced by a set of budget generators. FEDS research budgets are developed

Table 34--Estimated corn production costs per planted acre, by cost item, 1979

Cost item	Northeast	Corn Belt-Lake States	Northern Plains 1/	Southeast 2/	Southwest 3/	United States
			Dollars/acre			
Variable	117.58	111.80	109.17	119.87	148.24	113.11
Seed	12.42	12.62	11.62	12.68	10.64	12.41
Fertilizer	42.03	40.02	23.50	45.44	30.60	37.55
Lime	1.35	1.24	.04	3.04	0	1.18
Chemicals	14.33	14.23	8.84	13.16	17.34	13.27
Custom operations	5.88	3.95	3.56	7.82	9.22	4.44
All labor	13.98	11.09	13.74	12.93	20.38	12.03
Fuel and lubrication	10.00	9.23	24.88	9.58	34.03	12.53
Repairs	7.71	7.76	14.42	6.85	15.41	8.99
Drying	5.71	7.38	4.22	3.89	4.06	6.36
Purchased irrigation water	0	0	.31	0	1.21	.08
Interest	4.17	4.28	4.04	4.48	5.35	4.27
Machinery ownership	35.06	37.40	57.87	31.17	54.59	40.63
Replacement	19.78	21.02	33.11	18.14	31.53	23.01
Interest	12.28	13.16	20.61	10.46	19.22	14.29
Taxes and insurance	3.00	3.22	4.15	2.57	3.84	3.33
General farm overhead	13.09	7.69	6.73	9.54	9.58	7.94
Management charge	16.57	15.69	17.38	16.06	21.24	16.17
Total (excluding land)	182.30	172.58	191.15	176.64	233.65	177.85
Land allocation composite:						
Current value 4/	79.12	124.53	77.26	65.10	54.04	107.38
Average acquisition value 5/	39.92	67.62	46.83	34.81	26.10	58.89

1/ Includes Northern Plains region plus Colorado.
2/ Includes Appalachian.
3/ Includes California and Texas.
4/ Based on prevailing tenure arrangements in 1978, reflecting actual combinations of cash rent, net share rent, and owner-operator land allocations, land values, land tax rates, and cash rents updated to current year.
5/ Same as footnote 4, except average value of cropland during the last 35 years is used for owner-operator land instead of current land value.

Source: (40, Aug. 81, pp. 6-12).

Table 35--Estimated production costs per bushel, by cost item, specified regions, 1979

Cost item	Northeast	Corn Belt-Lake States	Northern Plains1/	Southeast 2/	Southwest 2/	United States
			Dollars/bushel			
Owner operator:						
Variable	1.24	.96	1.03	1.53	1.40	1.03
Machinery ownership	.37	.32	.55	.40	.52	.37
General farm overhead	.14	.07	.06	.12	.09	.07
Management charge	.18	.14	.17	.21	.20	.15
Total (excluding land)	1.93	1.49	1.81	2.26	2.21	1.62
Land allocation composite:						
Current value4/	.84	1.09	.68	.83	.48	.98
Acquisition value5/	.42	.60	.38	.44	.24	.54
Tenant operator:						
Cost to share renter6/	2.90	2.31	2.58	2.92	2.75	2.42
Cost to cash renter7/	2.29	2.07	1.74	2.84	2.54	2.17
Weighted renter cost8/	2.30	2.18	2.47	2.86	2.59	2.29
			Bushels/acre			
Average yield per planted acre	94.5	116.0	105.5	78.1	105.8	109.6
			Percent			
Percentage of U.S. production	3.0	70.2	16.4	6.8	2.0	98.4

1/ Includes Northern Plains region plus Colorado.
2/ Includes Appalachian and Southeast regions.
3/ California and Texas.
4/ Based on prevailing tenure arrangements in 1978, reflecting actual combinations of cash rent, net share rent, and owner-operator land allocations, land values, land tax rates, and cash rents updated to current year.
5/ Same as footnote 4, except average value of cropland during the last 35 years is used for owner-operator land instead of current land value.
6/ Share-renter portion of cost divided by share-renter portion of crop.
7/ Cash-renter costs including cash rent divided by total yield.
8/ Weighted average of share renter and cash renter based on prevailing tenure arrangements in 1978.

Source: (40, Aug. 1981, pp. 6-12).

Table 36--U.S. corn production cost per planted acre and per bushel

Cost category	Year1/					
	1975	1976	1977	1978	1979	19802/
			Dollars/acre			
Costs per acre:						
Variable expenses	91.21	86.39	89.25	98.39	113.11	136.51
Machinery ownership	22.77	24.23	25.83	31.00	40.63	48.96
Farm overhead	8.39	9.04	9.44	7.18	7.94	8.66
Management charge	14.76	14.82	12.98	13.66	16.17	19.41
Total (excluding land)	137.13	134.48	137.50	150.23	177.85	213.54
Land allocation composite:						
Current value	75.72	84.11	84.50	86.34	107.91	132.01
Acquisition value	54.20	59.42	56.74	48.97	59.32	64.85
			Dollars/bushel			
Costs per bushel:3/						
Variable expenses	1.06	0.98	0.98	0.98	1.03	1.51
Machinery ownership	.26	.28	.28	.31	.37	.54
Farm overhead	.10	.10	.10	.07	.07	.10
Management charge	.17	.17	.14	.13	.15	.21
Total (excluding land)	1.59	1.53	1.51	1.49	1.62	2.36
Land allocation composite:						
Current value	.88	.96	.93	.86	.98	1.46
Acquisition value	.63	.68	.62	.49	.54	.72
			Bushels per acre			
Average yield	86.4	88.0	90.8	100.5	109.6	90.5

1/ Data for 1975-77 are based on 1974 cost of production survey. Data for 1978-80 are based on 1978 cost of production survey.
2/ Preliminary.
3/ Calculated using costs per acre data in table and average yield estimates presented above.

Source: (40).

annually for smaller production areas, in addition to the budgets developed to support costs of production research. Summaries of budgets for the main production areas in the six leading corn producing States are presented in tables 37 and 38. These six States annually account for about 70 percent of the U.S. corn produced. Return to risk varied from a low of -$18.76 in Minnesota to a high of $13.90 in Iowa. Minnesota had the lowest cost per acre among the areas selected; however, lower yield per acre coupled with a lower price per bushel resulted in the most unfavorable balance of cost and returns. Illinois showed the highest cost per acre, but that State also enjoyed the highest yields and prices among the six States.

Irrigation is quite common in central Nebraska. Comparable 1979 corn production costs and yields in central Nebraska without irrigation were $152.76 per acre and 57.0 bushels per acre, respectively. Irrigation increased costs by 105 percent and yields by almost 130 percent; thus, producers using irrigation experienced more favorable returns. The per acre return to risk for nonirrigated corn in central Nebraska was -$21.66 in 1979. Future increases in energy costs associated with pumping irrigation water will likely reduce the advantages enjoyed by producers using irrigation in corn production.

Farm Drying and Storage Methods

The rapid adoption of field shelling of corn during the study period represents one of the most radical changes in corn production practices. For example, the Illinois Crop Reporting Service estimates that almost 94 percent of the 1980 crop was field shelled, up from only 2 percent in 1956. Similar trends occurred in all other major corn producing States during the study period. Larger acreages per worker coupled with higher per acre machinery costs associated with field shelling have encouraged early harvesting. As a result, shelled corn is usually harvested with a moisture content above levels that are safe for storage, and most of it must be dried.

The need for additional conditioning and storage has been met, for the most part, by the construction of drying and storage facilities on farms. The decision to purchase onfarm drying and storage facilities requires a long-term commitment of capital. Construction of these facilities has been encouraged in recent years by the availability of loans from the Commodity Credit Corporation (CCC) at favorable interest rates. However, producers must evaluate the costs and returns of owning onfarm facilities relative to commercial drying and storage costs before investing in drying and storage capacity.

The cost of owning and operating onfarm drying and storage facilities varies considerably and depends upon the type of dryer as well as the capacity of the facilities. Estimated

Table 37--Costs and returns for producing corn, selected areas in eastern Corn Belt, 1979[1/]

Budget item	Unit	Illinois (FEDS area 300)		Indiana (FEDS area 100)		Ohio (FEDS area 100)	
		Per acre	Per bushel	Per acre	Per bushel	Per acre	Per bushel
Gross receipts:							
Production	Bushels	134.20	1	114.30	1	119.00	1
Price	Dollars/bushel	2.50	2.50	2.50	2.50	2.45	2.45
Total receipts	Dollars	335.50	2.50	285.75	2.50	291.55	2.45
Variable production costs:							
Preharvest	do.	103.53	.77	96.88	.85	103.09	.87
Harvest	do.	31.53	.24	27.54	.24	28.59	.24
Total variable costs	do.	135.06	1.01	124.42	1.09	131.68	1.11
Ownership costs:[2/]							
Tractors	do.	6.26	.05	6.40	.06	7.31	.06
Machinery and equipment	do.	39.31	.29	37.96	.33	37.48	.31
Irrigation equipment	do.	0	0	0	0	0	0
Total ownership costs	do.	45.57	.34	44.36	.39	44.79	.37
Other costs:							
Land charge (share rent)	do.	121.75	.91	100.79	.88	101.74	.85
General farm overhead	do.	7.94	.06	7.94	.07	7.94	.07
Management[3/]	do.	18.86	.14	17.67	.15	18.44	.15
Total other costs	do.	148.55	1.11	126.40	1.10	128.12	1.07
Total production cost	do.	329.18	2.46	295.18	2.58	304.59	2.55
Return to risk	do.	6.32	.04	-9.43	-.08	-13.04	-.10

1/ Data developed by Firm Enterprise Data System, (FEDS), National Economics Division, ERS, USDA, in cooperation with Oklahoma State University, Stillwater, Okla.

2/ Ownership costs include replacement cost, taxes, interest, and insurance.

3/ Ten percent of total cost excluding land charge.

Source: Crop budgets prepared by FEDS, National Economics Division, ERS, USDA.

Table 38--Costs and returns for producing corn, selected areas in western Corn Belt, 1979[1/]

Budget item	Unit	Iowa (FEDS area 200)		Minnesota (FEDS area 300)		Nebraska (FEDS area 400)	
		Per acre	Per bushel	Per acre	Per bushel	Per acre	Per bushel
Gross receipts:							
Production	Bushels	132.70	1	101.90	1	131.30	1
Price	Dollars/bushel	2.30	2.30	2.00	2.00	2.30	2.30
Total receipts	Dollars	305.21	2.30	203.80	2.00	301.99	2.30
Variable production costs:							
Preharvest	do.	92.62	.70	80.74	.79	97.54	.74
Harvest	do.	23.39	.18	24.46	.24	28.34	.22
Total variable costs	do.	116.01	.88	105.20	1.03	125.88	.96
Ownership costs:[2/]							
Tractors	do.	8.97	.07	6.65	.07	5.64	.04
Machinery and equipment	do.	29.68	.22	28.82	.28	43.38	.33
Irrigation equipment	do.	0	0	0	0	30.64	.23
Total ownership costs		38.65	.29	35.47	.35	79.66	.60
Other costs:							
Land charge (share rent)	do.	112.45	.85	60.20	.59	79.47	.61
General farm overhead	do.	7.94	.06	6.93	.07	6.80	.05
Management[3/]	do.	16.26	.12	14.76	.14	21.23	.16
Total other costs	do.	136.65	1.03	81.89	.80	107.50	.82
Total production costs	do.	291.31	2.20	222.56	2.18	313.04	2.38
Return to risk	do.	13.90	.10	-18.76	-.18	-11.05	-.08

1/ Data developed by Firm Enterprise Data System, (FEDS), National Economics Division, ERS, USDA, in cooperation with Oklahoma State University, Stillwater, Okla.

2/ Ownership costs include replacement cost, taxes, interest, and insurance.

3/ Ten percent of total cost excluding land charge.

Source: Crop budgets prepared by FEDS, National Economics Division, ERS, USDA.

costs of conditioning, storing, and handling corn under alternative drying systems in Illinois are summarized in table 39. These costs include annual ownership costs, total operating costs, estimated field losses, and other miscellaneous costs. Estimated elevator charges for drying and 6-month storage costs (March sales) are also shown for comparison. Onfarm costs were generally higher than elevator charges for capacities of 20,000 bushels or less. However, onfarm facilities with capacities of 40,000 to 100,000 bushels were cost competitive with estimated elevator charges of about 23 cents per bushel. The 100,000-bushel, batch-in-bin stir dryer system had average costs of 17.3 cents per bushel and was the most economical of all systems compared.

Low-temperature drying systems utilizing conventional or solar energy may be an alternative to high-temperature drying in many sections of the Corn Belt (61, pp. 37-39). Low-temperature

Table 39--Summary of costs of conditioning, storing, and handling corn under alternative drying systems for corn marketed as grain from Illinois farms, 1975 1/

Type of drying equipment	Capacity (1,000 bushels)						
	5	10	20	40	60	80	100
	Cents/bushel						
Batch-in-bin dryer	44.9	34.1	25.0	20.9	21.9	22.4	20.6
Batch-in-bin stir dryer	49.2	36.0	25.2	21.1	19.5	18.4	17.3
Low-temperature dryer	47.4	40.2	31.1	26.6	26.6	26.1	26.5
Automatic batch dryer	65.9	40.5	26.7	23.5	21.8	21.0	19.4
Continuous flow dryer	75.0	45.5	29.5	23.0	24.3	20.8	19.4
Elevator charges (March sales)	23.2	22.0	23.0	23.0	23.0	23.0	25.2

1/ Ownership costs for grain stocks are excluded from cost estimates.
Source: (30).

drying is a method of drying that combines effectively with other drying procedures. Low-temperature drying should be given consideration when existing drying facilities are remodeled or when new facilities are planned because this method has the flexibility of using alternative heat energy sources.

Commercial Handling and Storage Methods

Corn may be handled and stored several times by the commercial grain elevator industry as it moves from points of production to points of consumption. The costs of providing these important marketing services are of concern to the industry as a group, to individual firms within the industry, and to the customers who purchase these services.

In recent years, ERS has conducted a series of studies to develop information on the operating costs associated with handling and storing grain in commercial grain elevators (table 40).

The estimates reflect book cost for all cost items except depreciation and interest on investment. Expenses for these items were based on the estimated cost of replacing the elevator's physical plant assets at the price level and interest rate that existed during the designated year. Storage costs have increased rather dramatically in recent years and are highest at port elevators. In 1979/80, average storage costs at port terminals were estimated to be about 45 cents per bushel compared with about 25 cents for inland facilities. Receiving costs were generally lower at port facilities because of the large volumes handled. Current costs for a new facility would be somewhat higher than the 1979/80 estimates because of increases in the costs of construction and interest and the additional investment required to meet pollution and dust control regulations.

Transportation

The costs associated with moving corn from production points to consumption, processing, and export locations have increased rapidly in recent years. Rail freight rates almost tripled between August 1967 and October 1979. The most rapid rise occurred in 1974 and 1975, according to the Tennessee Valley Authority, when seven rate increases were granted to the railroad companies (see chart on next page).

The rates of shipping grain have not increased as rapidly as the rates for most processed goods because of several innovations in the transportation of grain. The 100-ton hopper car was introduced in the early sixties. In 1965, rates were approved for five-car shipments into the Southeast. The new rates applying on minimum shipments of 450 tons in five-car units represented a reduction of about 60 percent from the single-car rates at that time.

Tariff number	Effective date	Percentage increase	Coverage
		Percent	
X-256	8/19/67	3	All points
X-259-B	11/28/68	5	All points
X-262	11/18/69	6	All points
X-265-B	11/20/70	6	All points
X-267-B	4/21/71	Approximately 8	All points
X-281-B	10/23/72	Approximately 5	All points
X-295-A	8/19/73	3	All points
X-299-B	1/01/74	2.8	All points
X-302	2/26/74	10	Export only
X-303-B	3/09/74	4	All points
X-305-A	6/20/74	3.3 + 10	All points
X-310-A	4/27/75	7	All points
X-313	6/20/75	5 + 2.5	All points
X-318	3/21/76	7	East and South only
X-330	10/07/76	5	West only
X-336	1/07/77	4	All points
X-343	11/30/77	5	All points
X-349	6/17/78	2	South
		4	All other points
X-357-A	12/15/78	8	South
		10	All other points
X-368-A	10/15/79	Approximately 14	Domestic
		Approximately 16	Export

The most significant development of the seventies has been the rapid adoption of unit-train shipments involving 65 to 100 cars and multiple-car shipments of 10 to 24 cars. The rates for the multiple-car shipments are generally about 30 percent lower than single-car rates. The trainload rates are about 40 to 50 percent less than single-car rates and vary, depending upon the number of trainloads shipped, between the two points within a year. The lowest rates apply when 45 shipments are made per year. The trainload rates generally apply on shipments from selected interior points to export points on the east and gulf coasts (10).

Large quantities of corn move by barge on the Illinois, Ohio, Mississippi, and Tennessee Rivers. Barge rates are generally established through negotiations between shippers and barge

Table 40--Estimated weighted average cost per bushel for handling and storing grain in commercial elevators, by type of facility, selected years1/

Year and type of facility	Receiving			Loading out			Annual storage
	Truck	Rail	Barge	Truck	Rail	Barge	
	Cents/bushel						
1964/65:							
Country	2.3	4.9	--	2.5	3.2	--	6.7
Inland terminal	1.3	2.1	1.8	1.9	2.1	0.9	7.1
Port terminal	1.3	1.5	1.0	2.1	2.4	.8	8.9
All facilities	1.6	1.7	1.1	2.4	2.4	.8	7.5
1967/68:							
Country	2.5	--	--	2.7	4.0	--	11.8
Inland terminal	2.4	2.1	--	3.3	2.4	--	15.5
Port terminal	1.6	2.3	1.6	4.3	3.4	1.1	13.3
All facilities	2.2	2.2	1.6	3.4	3.1	1.1	14.0
1971/72:							
Country	2.1	2.0	4.0	2.4	2.7	1.0	14.5
Inland terminal	2.0	2.6	3.7	1.8	2.2	.8	13.7
Port terminal	2.5	2.1	1.6	5.6	2.5	1.1	21.3
All facilities	2.1	2.4	1.8	2.4	2.5	1.0	14.9
1974/75:2/							
Country	2.4	2.2	4.5	2.8	3.0	1.1	18.2
Inland terminal	2.3	3.0	4.3	2.0	2.5	.9	16.7
Port terminal	2.5	2.2	1.8	6.4	2.8	1.1	25.0
All facilities	2.4	2.5	2.0	2.7	2.9	1.1	18.4
1977/78:2/							
Country	3.4	--	--	3.7	4.1	1.6	20.4
Inland terminal	2.1	4.0	5.9	3.4	3.5	1.6	19.0
Port terminal	4.2	2.9	2.3	--	3.7	1.6	33.7
All facilities	3.4	3.3	2.5	3.7	3.9	1.6	21.1
1979/80:2/							
Country	3.9	--	--	4.1	4.9	1.9	26.3
Inland terminal	3.3	4.8	7.4	3.1	3.9	1.9	24.8
Port terminal	3.6	3.3	2.7	--	4.9	1.8	45.6
All facilities	3.8	3.8	2.8	4.0	4.6	1.9	27.3

-- = not applicable.

1/ Depreciation and interest on investment based on replacing buildings and equipment at price levels and interest rates existing in designated years.

2/ Estimated on basis of cost data developed from a 1971/72 survey of the commercial storage industry and updated using producer price indices and current volume estimates.

Sources: (28, 29, 41).

companies. On average, these rates have been considerably lower than rail rates; however, they fluctuate greatly in response to seasonal changes in the demand for barge transportation.

Truck rates for hauling grain are unregulated and vary according to the extent of competition, availability of equipment, and regional variations in trucking costs. Truck companies often quote rates on the basis of mileage.

Two recent developments will have substantial impacts on the rates and intermodal rate structure for transporting corn in the eighties. First, the Inland Waterways Revenue Act of 1978 authorized construction of a new Lock and Dam 26 at Alton, Ill. This act also imposed an escalating fuel tax on commercial users of the inland waterway system. These taxes, when fully implemented, will recover 100 percent of the costs of operation, maintenance, and navigational aid on the inland waterway system. These user charges will likely be passed along to shippers in the form of higher rates.

The second development that has implications for corn transportation rates is the Railroad Decontrol Act of 1980. In the past, any industrywide or individual rate increase required the approval of the Interstate Commerce Commission (ICC). Under this method, railroads agreed on general rate increases through three regional rate-setting groups, and then submitted the proposed increases to ICC for approval. The Decontrol Act directed the ICC to permit automatic rate increases tied to inflation, but left it to the ICC to determine how inflationary costs are measured. The law gives railroads the right to raise rates freely by 6 percent a year on top of inflation for 4 years, and by 4 percent a year beyond inflation after that. The law restricts annual increases to an 18-percent maximum. The commission has indicated that it will allow railroads to set quarterly freight rate increases (36, Apr. 20, 1981, p. 3).

Processing

Processing is an important marketing function that converts corn into products that are consumed in the United States. Although processing costs are very important in determining the price and competitive position of corn products in the marketplace, very little published research is available on this topic. Consequently, this discussion will be limited to selected data from recent studies of feed manufacturing and wet-corn processing. Cost estimates for dry-corn milling are not available.

Feed Manufacturing

Estimates of investment requirements and operating cost per ton of feed produced have been developed for model feed plants ranging in capacity from 6 tons per hour to 50 tons per

hour (57). Four plant sizes were studied: the size groupings were 6 to 10 tons per hour, 10 to 25 tons per hour, 25 to 35 tons per hour, and 35 to 50 tons per hour. For each size plant, three production plants were developed so that the effects of specialization, economies of scale, and variations in pelleting or packing could be measured.

The model plants were based on an assumed 8-hour shift per day for 260 days per year. The output from a plant of a particular size differed due to variations in the average cubic-foot weight of the feed ingredients and finished products. For example, dairy feed may weigh between 20 and 30 pounds per cubic foot while poultry feed may weigh between 38 and 42 pounds per cubic foot. Thus, a plant with a capacity of 25 to 35 tons per hour was assumed to be able to produce 25 tons of dairy feed, 35 tons of poultry or swine feed, and 30 tons of mixed feed for various kinds of livestock.

Operating cost estimates for producing alternative types of feed in mash and pelleted form for either bulk or bagged delivery are shown in table 41. Operating cost per ton for producing bulk dairy feed in mash form varied from $9.57 per ton for small plants to $6.05 per ton for large plants. Comparable costs for producing poultry feed were $7.20 and $4.80 per ton, respectively. Pelleting increased costs from $1.15 to $2.05 per ton depending upon feed type and plant size. Bagged feed cost small plants an additional $2.50 per ton and large plants an additional $1.80 per ton.

Wet-Corn Processing

Published data on the costs of operating wet-corn processing plants and dry-corn mills are almost nonexistent. The adoption of technology to produce HFCS has stimulated interest in the competitive position of the product relative to sugar. A recent study at Purdue University developed cost estimates for model plants with daily processing capacities of 36,000, 72,000, and 108,000 bushels of corn per day (7). This assumed that all starch was converted to HFCS, and all revenues from byproduct sales were subtracted from total plant cost to derive estimates of HFCS production cost (table 42). Given average price levels for corn and byproducts that existed in 1977/78, production cost ranged from 8.66 cents per pound for a small plant (36,000 bushels per day) to 7.78 cents per pound of HFCS for a large plant (108,000 bushels per day). Using May 1978 price levels increased cost by about 1 cent per pound for all plant sizes.

Table 41--Operating costs for model feed plants of various sizes producing specified feed types in bulk and pellet form, 1975

Model plant and feed type	Capacity per hour	Mash		Pellets	
		Bulk	Bagged	Bulk	Bagged
	Tons	Dollars/ton			
Model I:					
Dairy	6	9.57	12.91	--	--
Mixed	8	9.03	11.58	11.08	13.61
Poultry	10	7.20	9.71	8.30	10.78
Model II:					
Dairy	10	9.16	12.76	--	--
Mixed	18	6.61	8.96	8.16	10.74
Poultry	25	5.53	7.41	6.68	8.77
Model III:					
Dairy	25	6.47	8.76	--	--
Mixed	30	6.01	7.96	7.36	9.30
Poultry	35	5.52	7.30	6.55	8.50
Model IV:					
Dairy	35	6.05	8.15	--	--
Mixed	43	5.29	7.24	6.49	8.41
Poultry	50	4.80	6.67	5.95	7.77

-- = not applicable.

Source: (57).

Table 42--Estimated cost of producing HFCS at alternative price levels for corn and byproducts, by plant size, 1978 1/

Price level	Processing capacity (bushels per day)		
	36,000	72,000	108,000
	Cents/pound		
Low2/	8.29	7.49	7.41
1977/78 average3/	8.66	7.85	7.78
May 1978 average4/	9.65	8.84	8.77

1/ Assumes plants are operated 24 hours per day for 330 days during the year.
2/ Assumed prices are: corn=$1.84 per bushel, corn oil=26.5 cents per pound, gluten feed=$78 per ton, and gluten meal=$183 per ton.
3/ Average 1977/78 prices: corn=$2.26 per bushel, corn oil=34.5 cents per pound, gluten feed=$91.42 per ton, and gluten meal=$183 per ton.
4/ May 1978 price level: corn=$2.57 per bushel, corn oil=35.5 cents per pound, gluten feed=$90 per ton, and gluten meal=$220 per ton.
Source: (7).

POLICY

U.S. agriculture has been influenced by Government programs since the early thirties when the Agricultural Adjustment Act of 1933 was passed in response to the severe economic problems of the farm sector during the Depression. Realized net income to farm operators in 1932 was less than one-third of what it had been in 1929 (27, p. 1).

Programs of the Fifties

The programs of the fifties involved mandatory price support, surplus disposal programs, and acreage control programs.

Price Supports

Under the authority of the Agricultural Act of 1949, price supports for corn were maintained at 90 percent of parity through 1950 and 1951. In 1952, this support level was extended to cover the crops of 1953 and 1954. The Agricultural Act of 1954 introduced flexible support prices that ranged from 82.5 to 90 percent of parity for the 1955 crop and from 75 to 90 percent of parity for the 1956 crop. The actual support level was based on carryover stocks with certain exclusions. These provisions were continued for the crops of 1957 and 1958.

In November 1958, corn farmers were given two options in a referendum. The first option was to keep program provisions

requiring acreage allotments and price supports of 75 to 90 percent of parity. The second option proposed discontinuing acreage allotments for 1959 and subsequent crops and receiving support at 90 percent of the average farm price for the preceding years, but at not less than 65 percent of parity. The latter option was chosen and remained in effect until the Feed Grain Act was passed for the 1961 crop.

Surplus Disposal Programs

The buildup of surplus stocks in the early fifties led to the passage of the Agricultural Trade Development and Assistance Act in 1954. This legislation, commonly known as Public Law (P.L.) 480, became a major vehicle for sending farm products abroad. Under this act, which is still in use today, surplus farm products could be shipped for emergency relief, sold for foreign currency, or bartered for strategic materials.

Acreage Controls

Acreage allotments were generally a feature of the programs of the fifties except during the Korean War. The main program to control acreage during the fifties was the Soil Bank, which was established in the 1956 Act, with an objective to reduce the amount of land planted to allotment crops such as corn. The program was divided into two parts: an acreage reserve and a conservation reserve. Under the acreage reserve, corn farmers reduced planted acreage below their base acreage and received payments for diverting this acreage to conservation uses. The program attracted over 21 million acres of cropland (not all from corn), in 1957, and it was terminated in 1958. The conservation reserve option allowed farmers to place land in a conservation use up to a maximum of 10 years and receive payments. This option had attracted about 28 million acres by the summer of 1960.

Programs of the Sixties

Legislation enacted during the sixties continued the price support features of earlier programs. From 1961 through 1965, corn support prices were required to be between 65 and 90 percent of parity. A new feature of the Feed Grain Act of 1961 was a special program for diverting corn and sorghum acreage to soil conserving crops or practices. To be eligible for price supports, corn producers had to divert at least 20 percent of average corn acreage planted in 1959 and 1960. Legislation passed in 1962 continued the acreage diversion program as a condition of eligibility for price supports. In 1963, the program was modified to authorize the Secretary of Agriculture to require additional acreage diversion if needed, and these provisions continued through 1965.

Provisions of the Food and Agriculture Act of 1965 began in 1966 and continued through 1970. Under this act, the acreage diversion program was replaced by a cropland adjustment program. The Secretary was authorized to enter into contracts

with farmers for periods of 5 to 10 years to remove acreage from crops and place them into conservation uses. Payments to participating producers were limited to 40 percent of the value of the crop normally produced on the land.

Programs of the Seventies

Legislation in the 1970, 1973, and 1977 Acts contained many features of previous acts such as P.L. 480, price supports through nonrecourse loans, and support payments. However, the three acts contained modifications or new features that provided farmers with greater freedom in deciding which crops to grow, and related price supports to production costs rather than the parity concept.

The Agricultural Act of 1970

Corn producers were required to set aside a certain percentage of cropland for conservation practices to qualify for support under this program. Program participants could then grow whatever crop they chose on the cropland remaining in production. This freedom was limited because producers were required to plant corn or an eligible substitute crop to protect the farm's allotment. Failure to plant corn or an acceptable substitute crop resulted in a 20-percent reduction in the farm allotment after 1 year and a complete loss of the allotment after 3 years.

Price supports for corn were specified to be the higher of $1.35 per bushel, or 70 percent of the parity price as of October 1 each year. The Secretary was given authority to set loan rates at not less than $1.00 per bushel or more than 90 percent of parity. Participating producers received support payments equal to the difference in the support price and market price on one-half the base production (normal production on base acreage). Eligibility for payments was dependent upon meeting the acreage set-aside provisions of the program.

The Agriculture and Consumer Protection Act of 1973

The 1973 Act represented a dramatic shift from production control to expansion of grain production to meet a rapidly expanding world demand for grain. The old concept of support price based on parity was replaced by a new concept of target price based on costs of production. A target price of $1.38 per bushel was established for the 1974 and 1975 corn crops. Target prices for the 1976 and 1977 crops were designated to be the 1975 target price adjusted by an index of production costs. Production costs were computed on the basis of average yields for the three most recent crop years. The target prices established for the 1976 and 1977 crops were $1.57 and $2.00 per bushel, respectively.

The loan rate for corn was to be set by the Secretary at a level of at least $1.10 per bushel but not more than 90 percent of parity. The loan rate for corn was set at minimum levels in

1974 and 1975 so that producers would place greater reliance on the marketplace. The Secretary used his discretionary power and raised loan rates to $1.50 per bushel in 1976 and to $1.70 per bushel in 1977. The target price and loan rate for the 1977 crop was increased to $2.00 in later legislation.

Support payments under this act were equal to the difference in prices received by farmers during the first 5 months of the marketing year (October-February) and the target price for that crop. No payments were made in years when average market prices exceeded target levels.

Other provisions of the 1973 Act established disaster payments and disaster reserve inventories. Eligible producers received disaster payments when drought, flood, or other natural disasters prevented them from planting any portion of their allotment. Payments were also available when natural disaster prevented the harvest of two-thirds of an eligible producer's normal production. The provision establishing disaster reserve inventories was limited to no more than 75 million bushels of wheat, feed grains, and soybeans.

The Food and Agriculture Act of 1977

The 1977 Act continued the system providing support for farm prices through commodity loans and target prices, which were used to compute deficiency payments when market prices fell below target levels. Deficiency payment rates were the difference between the target price and the higher of the 5-month national average price received by all farmers or the national loan rate for corn. The Secretary was directed to use the smaller of the above figures and make payments only when the 5-month average price received by all farmers (October-February) was below the target price.

The 1977 Act raised the target price for the 1977 crop to $2.00 per bushel--an increase of 30 cents above the level set by the 1973 legislation. The 1978 target price was set at $2.10 in the act. Target prices for the 1979-81 crops were based on the $2.10 level and adjusted to reflect any changes in the moving 2-year average of production costs. A return to land and management was included in the establishment of the 1978 target price. The adjustments for the 1979-81 crops were based on changes in nonland costs.

The average loan rate was raised to $2.00 per bushel for the 1977 crop, the minimum for the 1978-81 crops. The act specified that the loan rate could not exceed 100 percent of parity.

The 1977 Act authorized the Secretary to establish a set-aside program if supplies were likely to be excessive. Under this

act, a producer's set-aside acreage was to be based on acreage planted for harvest. This was a significant change from the 1973 Act where set-aside acreage was expressed as a percentage of the farm allotment. This provided farmers with greater freedom in deciding which crops to plant. In years when a set-aside program is in effect, deficiency payments to participating producers are based on acreage planted for harvest, established yields on the farm, and an allocation factor.

A new feature of the 1977 Act directed the Secretary to administer a farmer-owned reserve program for wheat and, at the Secretary's discretion, feed grains. The reserve program was put into effect through an extended price support loan program involving 3-year contracts to extend producer loans beyond normal loan maturity dates. The Secretary was authorized to pay storage costs to participants and to adjust interest rates when appropriate. When the program was set up, storage payments on reserve corn were stopped when U.S. average prices received by farmers reached 125 percent of the current loan rate; the loans were called when the average price reached 140 percent of the national loan rate. Thus, storage payments on corn reserves were stopped when the average farm price reached $2.50 in the summer of 1979.

Producer-owned grain under loan from the 1976 and 1977 crops was eligible for the reserve program, and early entry of the 1978 corn crop was allowed until Nov. 30, 1978. Additional 1978-crop corn was not allowed entry into the reserve program. Eligible producers were allowed to enter corn from the 1979 and 1980 crops into the reserve program. When the farmer-owned grain reserve is in effect, the CCC cannot sell Government-owned stocks of corn at less than 150 percent of the loan rate.

The 1977 Act extended the disaster payment program through the 1979 crop and required the Secretary to make storage facility loans to producers with a maximum repayment period of 10 years. These loans cover 80 percent of the investment and are made at relatively favorable interest rates (see 21 for additional information).

Price Support Operations

Corn producers have enjoyed a degree of price protection for their production throughout the study period. The price support operations of CCC are administered by USDA's Agricultural Stabilization and Conservation Service (ASCS). The nature of price supports has varied since 1950. Prices were supported entirely through nonrecourse loans and direct purchases by CCC prior to 1961. During this period, the loan or purchase rate varied from a high of $1.62 per bushel in 1954 to a low of $1.06 per bushel in 1960. The rate was reduced each year during the 1954-60 period as Government-owned

stocks of corn continued to increase. The loan rate exceeded the season average price received by farmers every year during 1952-62 (table 43). Consequently, a large proportion of the corn put under price support in those years was acquired by CCC. Acquisitions by CCC during this period peaked at 635 million bushels in 1961/62.

The support program shift for the 1963 crop from total support through commodity loans to a lower loan rate combined with payments for acreage diversion resulting in a sizable reduction in the quantity put under price support loans. The most dramatic impact of the program shift was a reduction in CCC acquisitions, from 460 million bushels in 1962/63 to 16 million bushels in 1963/64. CCC acquisitions have been very low since that time except during 1967/68 when 193 million bushels were acquired, reflecting a significant increase in production in 1967 due to increases in both acreage and average yield (see table 2).

Payments to program participants have varied greatly over the years. Payments under the Soil Bank Program reached $280 million in 1958/59, the last year of that program (table 43). The feed grain programs that have been in effect since 1961 have contained provisions for deficiency payments to program participants when prices received were below target levels, disaster payments for crop failures, and diversion payments for removing a certain percentage of base acreage from corn production. Payments under these program provisions reached a record $1.47 billion in 1972/73, when the difference between the loan rate and support rate was 40 cents per bushel. The shift from support prices based on parity to target prices based on costs of production in the 1973 Act substantially reduced payments to participants. Total payments had fallen to $90 million by 1975/76.

Once corn is pledged under a nonrecourse loan from CCC, the producer has several options. First, the producer can redeem the loan by repaying CCC, and then feed or market the corn in the usual manner. The loan program provides a source of interim financing for farmers who store corn for use in livestock feeding operations at a later date. Second, the farmer can forfeit the loans and deliver the corn to CCC. The producer must deliver the grain to a CCC-approved commercial warehouse if the corn is stored onfarm. The warehouse operator issues a receipt indicating the quantity and quality delivered, and a final settlement between the producer and CCC is made on the basis of the warehouse receipt. The disposition of corn placed under price support by farmers since 1953 is shown in table 44.

Table 43--Price support operations for corn

Year beginning Oct. 1	Price support rates			Put under support		Acquired by CCC1/	Total payments to participants2/
	Loan rate	Support payments	Total support	Quantity	Percentage of production		
	---- Dollars/bushel -----			Mil. bu.	Percent	Mil. bu.	Mil. dol.
1950/51	1.47	0	1.47	54	2.0	1	0
1951/52	1.57	0	1.57	26	1.0	1	0
1952/53	1.60	0	1.60	417	14.0	375	0
1953/54	1.60	0	1.60	471	16.3	422	0
1954/55	1.62	0	1.62	259	9.6	251	0
1955/56	1.58	0	1.58	421	14.7	407	0
1956/57	1.50	0	1.50	477	15.5	474	170
1957/58	1.40	0	1.40	369	12.1	268	194
1958/59	1.36	0	1.36	381	11.4	267	280
1959/60	1.12	0	1.12	529	13.8	461	0
1960/61	1.06	0	1.06	637	16.3	475	0
1961/62	1.20	0	1.20	659	18.3	635	645
1962/63	1.20	0	1.20	591	16.4	460	684
1963/64	1.07	.18	1.25	395	9.8	16	680
1964/65	1.10	.15	1.25	216	6.2	12	926
1965/66	1.05	.20	1.25	215	5.2	8	1,094
1966/67	1.00	.30	1.30	263	6.4	12	1,028
1967/68	1.05	.30	1.35	497	10.4	193	731
1968/69	1.05	.30	1.35	404	9.2	36	1,166
1969/70	1.05	.30	1.35	398	8.7	5	1,365
1970/71	1.05	.30	1.35	324	7.9	7	1,228
1971/72	1.03	.32	1.35	953	16.9	35	893
1972/73	1.01	.40	1.41	420	7.5	1	1,469
1973/74	1.32	.32	1.64	261	4.6	0	910
1974/75	1.10	.28	3/1.38	77	1.7	0	244
1975/76	1.10	.28	1.38	147	2.5	0	90
1976/77	1.50	.07	1.57	278	4.4	4/	181
1977/78	2.00	0	2.00	1,159	17.7	94	281
1978/79	2.00	.10	2.10	641	8.8	0	683
1979/80	2.10	.10	2.20	557	7.0	0	126
1980/81	2.25	.10	2.35	747	11.2	N.A.	350
1981/82	2.40	0	2.40	N.A.	N.A.	N.A.	N.A.

N.A. = not available.

1/ Includes deliveries from original loan program, the reseal loan program, and over-deliveries as determined by weight of farm-stored grain when delivered to CCC.

2/ Payments made in 1956-58 were for the acreage reserve under the Soil Bank program. Beginning in 1961/62 payments have been made to eligible producers under deficiency, disaster, and diversion provisions of the Feed Grain Programs.

3/ Beginning in 1974, total support is the target price on allotment production.

4/ Less than 500,000 bushels.

Source: Agricultural Stabilization and Conservation Service, U.S. Department of Agriculture.

Table 44--Disposition of quantities of corn placed under price support

Crop year	Total placed under price support 1/	Redeemed by farmers 2/	Delivered to CCC	Extended loans: reseal and reserve	Total deliveries to CCC 3/
			Million bushels		
1953	471	56	335	80	422
1954	259	17	196	45	251
1955	421	32	217	72	407
1956	477	36	359	82	474
1957	369	104	207	58	268
1958	381	125	175	81	267
1959	530	86	323	120	461
1960	638	114	324	200	475
1961	659	26	478	155	635
1962	591	106	345	319	460
1963	395	242	15	139	16
1964	216	142	2	72	12
1965	215	153	4/	62	8
1966	263	129	4/	134	12
1967	497	105	117	276	193
1968	404	263	11	130	36
1969	398	290	2	106	5
1970	324	206	6	112	7
1971	953	547	17	389	35
1972	420	419	1	0	1
1973	261	216	0	0	0
1974	77	77	0	0	0
1975	147	147	0	0	0
1976	278	269	4/	5/10	4/
1977	1,159	689	94	489	94
1978	641	519	1	194	1
1979	557	374	0	324	0
1980	747	26	0	465	0

1/ Includes quantities pledged under loan and purchase agreement programs.
2/ Grain in which loans were repaid or purchase agreement grain not delivered. Includes withdrawals from reserve program since 1976.
3/ Includes deliveries from original program, the reseal program, and overdeliveries as determined by weight of farm-stored grain when delivered to CCC.
4/ Less than 500,000 bushels.
5/ Quantity of each crop placed in a farmer-owned reserve program. As of February 4, 1981, the reserve program consisted of 8 million bushels from the 1976 crop, 220 million bushels from the 1977 crop, 118 million bushels from the 1978 crop, 168 million bushels from the 1979 crop, and 465 million bushels from the 1980 crop.

Source: Agricultural Stabilization and Conservation Service, U.S. Department of Agriculture.

From 1953 through 1971, the reseal loan program provided a third option. Under this program, producers were given the option of extending their loans beyond the maturity date of the original loan. This option was used extensively in some years and accounted for a record 389 million bushels in 1971, the last crop on which loans could be extended under the reseal program. This option provided producers additional flexibility during periods when corn prices were depressed. It also provided a source of income because CCC paid storage charges for corn covered by a reseal loan. The expense to producers was limited to grain ownership costs incurred as interest on the CCC loans.

Prior to the 1977 crop, the 1971 crop represented a record year both in quantity placed under price support (953 million bushels) and quantity placed under the reseal or extended loan program (389 million bushels). A record 1.2 billion bushels of 1977-crop corn was put in the CCC loan program. This level of program participation reflects in part the establishment of the farmer-owned reserve program. The reserve program is similar to the old reseal loan program in that 1977-crop corn had to be in the regular loan program before it could be placed in the reserve program at the loan maturity date. This requirement was modified for the 1978 crop, and early entry of 1978-crop corn in the reserve program was last allowed on Nov. 30, 1978. As of May 2, 1979, loans were still outstanding on 17 million bushels of 1977-crop corn which could eventually enter the reserve program.

The major difference between the reserve program and the old extended loan program involves the withdrawal of grain from the programs. The reseal loan program allowed producers to withdraw corn from the program by redeeming their loans or delivering to CCC at any time prior to loan maturity date. In contrast, producers cannot withdraw grain from the reserve program during the contract period unless the U.S. farm price rises above the release price of $2.81 which is currently 125 percent of the loan rate. The reserve loans were called by CCC during the winter of 1981 when the average farm price rose above the call level of 145 percent of the loan rate. Corn entered into the reserve prior to Jan. 7, 1980, was subject to a call price of $3.15 per bushel, and corn entered after that date was subject to a call price of $3.26 per bushel.

The proportion of carryover stocks owned by the CCC is a good indication of the degree of influence Government price support programs have on the corn industry at any point. During the fifties, corn prices were supported well above market clearing levels without restrictions on acreage. Surpluses accumulated and U.S. carryover stocks of corn reached a record 2 billion bushels on Sept. 30, 1961. The CCC owned about two-thirds of

these stocks outright; more than 93 percent of the total was either owned by CCC or pledged under Government price support loans (table 45). In fact, during the fifties and early sixties, the grain marketing industry had no incentive to maintain inventories in excess of minimum working levels.

The Soil Bank (acreage reserve) Program of 1956-58, was the first major attempt to control production by withholding land. This program reduced the acreage of corn harvested for grain 10 percent below other years during that decade. Less productive land was taken out of production, and an increase in average yield more than offset the benefits of reduced acreage, and production as well as carryover stocks continued to increase. The Soil Bank Program was discontinued in 1959, and the conservation reserve was the only program in effect during 1959/60. Although the conservation reserve attracted 28.7 million acres, it had little influence on corn acreage (table 46). The acreage of corn harvested for grain rebounded to levels of the early fifties during 1959/60, and surplus stocks rose to record levels.

A new direction in price support operations was begun in 1961 when acreage diversion was incorporated into the feed grain program. Over 25 million acres were taken out of corn and sorghum production the first year. Acreage withheld from production under the feed grain program reached a record 39 million acres in 1961. The acreage diversion program was effective in reducing the level of carryover stocks; however, program costs associated with acreage diversion and deficiency payments soared in the late sixties and early seventies.

Participating producers were given greater freedom in making production decisions under the 1970 Act. Program participants were required to set aside or place a certain percentage of their feed grain acreage into conservation practices, and then they could grow whatever crop they chose on the remaining cropland. Cropland set aside in conservation practices under the feed grain program reached a peak of 36.6 million acres in 1972.

The shift from program restrictions to greater reliance on market signals to guide producers continued when price and income supports were fully separated under the 1973 Act. By 1974, the only cropland withheld under specific programs was the 2.4 million acres that remained in the cropland conservation and cropland adjustment programs that were begun in the midsixties. These programs expired in the late seventies.

Table 45--Government-owned, Government-controlled, and privately owned stocks of corn

Crop year ending Sept. 30	CCC-owned stocks	Under price support1/	Extended loan program2/	Total Government	Privately owned stocks	Total U.S. stocks
			Million bushels			
1956/57	818	3/242	N.A.	1,060	105	1,165
1957/58	932	3/363	N.A.	1,295	124	1,419
1958/59	1,101	3/254	N.A.	1,355	114	1,469
1959/60	1,153	3/247	N.A.	1,400	124	1,524
1960/61	1,286	3/389	N.A.	1,675	112	1,787
1961/62	1,327	3/563	N.A.	1,890	126	2,016
1962/63	888	3/647	N.A.	1,535	118	1,653
1963/64	810	3/465	N.A.	1,275	90	1,365
1964/65	828	3/472	N.A.	1,300	237	1,537
1965/66	540	3/384	N.A.	924	233	1,147
1966/67	148	55	234	437	403	840
1967/68	139	134	101	374	449	823
1968/69	182	324	208	714	448	1,162
1969/70	295	148	293	736	377	1,113
1970/71	255	52	293	600	399	999
1971/72	105	30	203	338	329	667
1972/73	160	29	533	722	404	1,126
1973/74	84	39	48	171	538	109
1974/75	6	2	0	8	476	484
1975/76	0	2	0	2	359	361
1976/77	0	22	0	22	378	400
1977/78	0	117	0	117	769	886
1978/79	13	404	224	641	470	1,111
1979/80	100	117	592	809	495	1,304
1980/81 4/	256	66	681	1,003	614	1,617

N.A. = not available.

1/ Quantity outstanding under loan from preceding crop that has not been redeemed, delivered to CCC, or placed in the extended (reseal) loan program.

2/ Quantity outstanding under the extended (reseal) loan program from all previous crop years.

3/ Quantities outstanding under price support loans and old grain resealed were combined on Sept. 30 prior to 1966.

4/ Preliminary.

Sources: (43, 44, 45, 46, 51).

Table 46--Cropland acreage withheld from production under specific programs1/

Year	Acreage reserve	Conservation reserve	Feed grain					Wheat	Cotton	Cropland conversion	Cropland adjustment	Total 2/
			Corn	Sorghum	Barley	Oats	Total					
			Million acres									
1956	12.2	1.4	0	0	0	0	0	0	0	0	0	13.6
1957	21.4	6.4	0	0	0	0	0	0	0	0	0	27.8
1958	17.2	9.9	0	0	0	0	0	0	0	0	0	27.1
1959	0	22.5	0	0	0	0	0	0	0	0	0	22.5
1960	0	28.7	0	0	0	0	0	0	0	0	0	28.7
1961	0	28.5	19.1	6.1	0	0	25.2	0	0	0	0	53.7
1962	0	25.8	20.3	5.5	2.4	0	28.2	10.7	0	0	0	64.7
1963	0	24.3	17.2	4.6	2.7	0	24.5	7.2	0	.1	0	56.1
1964	0	17.4	22.2	6.5	3.7	0	32.4	5.1	.5	.1	0	55.5
1965	0	14.0	24.0	7.0	3.7	.1	34.8	7.2	1.0	.4	0	57.4
1966	0	13.3	23.7	7.3	3.7	3/	34.7	8.3	4.6	.4	2.0	63.3
1967	0	11.0	16.2	4.1	0	0	20.3	0	4.8	.6	4.0	40.7
1968	0	9.2	25.4	7.0	0	0	32.4	0	3.3	.5	4.0	49.4
1969	0	3.4	27.2	7.5	4.4	0	39.1	11.1	0	.5	3.9	58.0
1970	0	.1	26.1	7.4	3.9	0	37.4	15.7	0	3/	3.9	57.1
1971	0	3/	14.1	4.1	0	0	18.2	13.5	2.1	3/	3.8	37.6
1972	0	3/	24.4	7.3	4.9	0	36.6	20.1	2.0	3/	3.3	62.1
1973	0	0	6.0	2.0	1.4	0	9.4	7.4	0	3/	2.8	19.6
1974	0	0	0	0	0	0	0	0	0	3/	2.4	2.4
1975	0	0	0	0	0	0	0	0	0	3/	2.4	2.4

1/ Totals may not add due to rounding.
2/ Total cropland withheld, including acreage devoted to substitute crops.
3/ 50,000 acres or less.

Source: (39).

Programs for the Eighties

The 1981 grain crops are the last to be covered by the Food and Agriculture Act of 1977. Congress will be considering new legislation that will apply to crops in 1982 and beyond.

Agricultural Act of 1980

The Agricultural Act of 1980 was signed into law on December 3, 1980. This legislation dealt primarily with the farmer-owned reserve program and CCC sales policies. The act raised the loan rate on corn placed in the farmer-owned reserve to $2.40 and $2.55 per bushel for the 1980 and 1981 crops, respectively. Thus, the loan rate for reserve corn was set at 15 cents per bushel above the rate for regular loans. The act also waived first-year interest charges for 1980- and 1981-crop corn placed in the reserve. 4/

The legislation raised the minimum sales price on grain owned by the CCC to at least 105 percent of the call level. CCC could have sold corn at 150 percent of the loan rate under prior legislation, raising the minimum sales price on CCC-owned corn by 5 cents per bushel.

1981 Feed Grain Program

The provisions of the 1981 feed grain program continued the emphasis on production at full capacity. No set-aside acreage was required for eligibility for program benefits. Farmers will be eligible for loans, target price and disaster protection, and the reserve program on their entire acreage. Since the loan rate and target prices were set at the same level, target price deficiency payments will not be made on the 1981 crop. Producers will be eligible for the higher reserve-loan rate if prices are below the call price of $3.48 per bushel. They will also receive payments for storage costs on corn placed in the reserve program if the average farm price drops below the reserve release price of $3.00 per bushel.

Beyond 1981

Policy problems and alternatives for legislation relating to crops in 1982 and beyond are many. As new legislation is formulated, Congress will be addressing issues related to farm prices and income, international trade policies, domestic food prices, grain reserve policies, and domestic food stamp programs. Many of these are key provisions of the 1977 Act, so new legislation will likely be a continuation of current programs in many respects. However, some new initiatives are likely since the concerns of farmers, consumers, and policymakers have changed since 1977.

4/ The Agriculture and Food Act of 1981 was signed into law in December 1981 after this report was written.

REFERENCES

(1) Brandow, George E. Interrelationships Among Demands for Farm Products and Implications for Control of Market Supply, Bul. 680, Pennsylvania State Univ., State College, 1961.

(2) Butell, Robert, and Abner Womack. "October - December Feed Demand for Corn," Feed Situation, FdS-259, U.S. Dept. Agr., Econ. Res. Serv., Nov. 1975, pp. 19-23.

(3) _____. "January - March Demand for Corn," Feed Situation, FdS-260, U.S. Dept. Agr., Econ. Res. Serv., Feb. 1976, pp. 20-23.

(4) _____. "April - June Feed Demand for Corn," Feed Situation, FdS-261, U.S. Dept. Agr., Econ. Res. Serv., May 1976, pp. 21-24.

(5) _____. "July - September Feed Demand for Corn," Feed Situation, FdS-262, U.S. Dept. Agr., Econ. Res. Serv., Sept. 1976, pp. 21-26.

(6) Commodity Futures Trading Commission. Commitments of Traders in Commodity Futures, (With Market Concentration Ratio), U.S. Dept. Agr., Chicago, Ill., various issues.

(7) Cubenas, Gervasio J. Costs of Producing High Fructose Corn Syrup; An Economic Engineering Analysis, Unpub. M.S. thesis, Purdue Univ., West Lafayette, Ind., May 1979.

(8) Foote, Richard J., et. al. The Demand and Price Structure for Corn and Total Feed Concentrates, TB-1061, U.S. Dept. Agr., Bur. of Agr. Econ., 1952.

(9) Fox, Karl A. The Analysis of Demand for Farm Products, TB-1081, U.S. Dept. Agr., Bur. of Agr. Econ., 1953.

(10) Free, W. J., L. E. Stone, and Dean Baldwin. Transportation Rates for Corn, Wheat and Soybeans, No. 227, Southern Cooperative Regional Series, TVA, Feb. 1978.

(11) Ghetti, Joseph L., Allen G. Schienbein, and Rodney C. Kite. Costs of Storing and Handling Grain in Commercial Elevators, 1967-68 and Projections for 1969-70, ERS-401, U.S. Dept. Agr., Econ. Res. Serv., Feb. 1969.

(12) Heid, Walter G., Jr. Changing Grain Marketing Channels, ERS-39, U.S. Dept. Agr., Econ. Res. Serv., Nov. 1961.

(13) Heid, Walter G., Jr., and Mack N. Leath. U.S. Barley Industry, AER-395, U.S. Dept. Agr., Econ. Stat. Coop. Serv., Feb. 1978.

(14) Heid, Walter G., Jr. U.S. Wheat Industry, AER-432, U.S. Dept. Agr., Econ. Stat. Coop. Serv., Aug. 1979.

(15) Heifner, Richard G., James L. Driscoll, John W. Helmuth, Mack N. Leath, Floyd F. Niernberger, and Bruce H. Wright. The U.S. Cash Grain Trade in 1974: Participants, Transactions, and Information Sources, AER-386, U.S. Dept. Agr., Econ. Res. Serv., Sept. 1977.

(16) Hieronymus, T. A. Economics of Futures Trading for Commercial and Personal Profit, New York, Commodity Research Bureau, 2nd ed., 1977.

(17) Hill, Lowell D., Mack N. Leath, and Stephen W. Fuller. Corn Movements in the United States: Interregional Flow Patterns and Transportation Requirements in 1977, Univ. of Illinois at Urbana-Champaign, North Central Reg. Res. Bul. 275, Southern Coop. Ser. Bul. 253, Illinois Bul. 768, Jan. 1981.

(18) Hill, Lowell D., Marvin Paulsen, and Margaret Early. Corn Quality: Changes During Export, Univ. of Illinois, Urbana-Champaign, Special Pub. 58, Sept. 1979.

(19) Holder, Shelby H., Jr., and Warren R. Grant. U.S. Rice Industry, AER-433, U.S. Dept. Agr., Econ. Stat. Coop. Serv., Aug. 1979.

(20) Jackson, David M., Warren R. Grant, and Carl E. Shafer. U.S. Sorghum Industry, AER-457, U.S. Dept. Agr., Econ. Stat. Coop. Serv., June 1980.

(21) Johnson, James, and Milton H. Ericksen. Commodity Programs Provisions Under the Food and Agriculture Act of 1977, AER-389, U.S. Dept. Agr., Econ. Stat. Coop. Serv., Oct. 1977.

(22) Leath, Mack N., and Leo V. Blakley. An Interregional Analysis of the U.S. Grain-Marketing Industry, 1966/67, TB-1444, U.S. Dept. Agr., Econ. Res. Serv., Nov. 1971.

(23) Liebenow, Robert C. "Corn Processors Expanding Rapidly," Milling and Baking News, vol. 54, Sosland Publishing Company, Kansas City, Mo., Apr. 1, 1975, pp. 28-29.

(24) Milling and Baking News. Milling Directory/Buyers Guide, vol. 57, no. 43, Sosland Publishing Company, Kansas City, Mo., Dec. 8, 1978, p. 88.

(25) Meinken, Kenneth M. The Demand and Price Structure for Oats, Barley, and Sorghum Grains, TB-1080, U.S. Dept. Agr., Bur. of Agr. Econ., 1953.

(26) Purcell, Wayne D., and Thomas Wilson Richardson. Quantitative Models to Predict Quarterly Average Cash Corn Prices and Related Hedging Strategies, Okla. State Univ., Stillwater, Bul. B-731, Dec. 1977.

(27) Rasmussen, Wayne D., and Gladys L. Baker. Price-Support and Adjustment Programs from 1933 Through 1978: A Short History, AIB-424, U.S. Dept. Agr., Econ. Stat. Coop. Serv., Feb. 1979.

(28) Schienbein, Allen G., and Carl J. Vosloh, Jr. Cost of Storing and Handling Grain and Controlling Dust in Commercial Elevators, 1971-72, ERS-513, U.S. Dept. Agr., Econ. Res. Serv., March 1973.

(29) Schienbein, Allen G. "Cost of Storing and Handling Grain in Commercial Elevators, Projections for 1974/75," Feed Situation, FdS-252, U.S. Dept. Agr., Econ. Res. Serv., Feb. 1974, pp. 31-41.

(30) Schwart, R. B., and L. D. Hill. Comparative Costs of Conditioning and Storing Corn, AERR-152, Dept. of Agr. Econ., Agr. Exp. Sta., Univ. of Illinois, Urbana-Champaign, July 1977.

(31) Sears, Horace E. World Grain Trade Statistics, 1950-51/1972-73, FAS M-258, U.S. Dept. Agr., For. Agr. Ser., Sept. 1974.

(32) Sharp, John W. Grain Facilities in the U.S. Specializing in Originating Grain for Export and Soybean Processing Plants, Res. Cir. 241, Ohio Agr. Res. and Dev. Center, Wooster, Sept. 1978.

(33) Stallings, James L., James M. Harris, and Charles Sappington. Grain Movements Between Southern and Corn Belt States, a Special Relationship, Southern Coop. Ser. Bul. 209, Mar. 1976.

(34) Subotnik, Abraham, and James P. Houck. A Quarterly Model for Corn: A Simultaneous Approach to Cash and Futures Markets, TB-318, Univ. of Minnesota, St. Paul, 1979.

(35) The Northwestern Miller. "List of Corn Mills," Minneapolis, Sept. 1965, pp. 68-80, and Sept. 1971, pp. 88-97.

(36) The Wall Street Journal, Dow Jones and Company, various issues.

(37) U.S. Department of Commerce. Wet Corn Milling, Census of Manuf., MC72(P)-20D-4, Bureau of the Census, 1972 prelim. report, 1974.

(38) U.S. Department of Agriculture. Agricultural Prices, Econ. Stat. Coop. Serv., various issues.

(39) _____. Agricultural Statistics, various issues.

(40) _____. Costs of Producing Selected Crops in the United States - 1974-80, reports prepared by ERS and ESCS for the Committee on Agriculture and Forestry, U. S. Senate, Jan. 1976, Jan. 1977, Apr. 1978 and July 1980.

(41) _____. Costs of Storing and Handling Grain in Commercial Elevators, 1964-65, ERS-288, Econ. Res. Serv., Apr. 1966.

(42) _____. Crop Production Annual Summary, Crop Reporting Board, Econ. Stat. Coop. Serv., selected issues.

(43) _____. Feed Situation, Econ. Stat. Coop. Serv., selected issues.

(44) _____. Feed Statistics Through 1966, SB-410, Econ. Res. Serv., Sept. 1967.

(45) _____. Supplement for 1969 to Feed Statistics, SB-410, Econ. Res. Serv., Oct. 1969.

(46) _____. Supplement for 1971 to Feed Statistics, SB-410, Econ. Res. Serv., July 1972.

(47) _____. Field Crops: Production, Disposition, Value, Crop Reporting Board, Econ. Stat. Coop. Serv., selected issues.

(48) _____. Field Crops, Estimates by States 1974-78, Acreage, Yield, and Production, SB-646, Crop Reporting Board, Econ. Stat. Serv., Dec. 1980.

(49) _____. Foreign Agriculture Circular, Grains, For. Agr. Serv., selected issues.

(50) _____. Foreign Agricultural Trade of the United States, Econ. Res. Serv., selected issues.

(51) _____. Grain Market News, weekly, Summary and Statistics, Agric. Mkt. Serv., Independence, Mo., selected issues.

(52) _____. Grain Stocks, Crop Reporting Board, Econ. Stat. Coop. Serv., selected issues.

(53) _____. Grain Storage Capacity Survey, Agr. Stab. Cons. Serv., a special report, Oct. 1978.

(54) _____. 1977 Marketing Channel Survey: Channels Used for Marketing Farm Commodities in Selected States, Crop Reporting Board, Econ. Stat. Coop. Serv., Mar. 1979.

(55) _____. The Official United States Standards for Grain, Fed. Grain Insp. Ser., Jan. 1978.

(56) _____. 26 Years of World Cereal Statistics: Area, Yield, Production, 1950-75, Econ. Res. Serv., a special report, July 1976.

(57) Vosloh, Carl J., Jr. Feed Manufacturing Costs and Capital Requirements, AER-335, U.S. Dept. Agr., Econ. Res. Serv. May 1976.

(58) _____. "Grain Marketing," Agricultural Markets in Change, AER-95, U.S. Dept. Agr., Econ. Res. Serv., July 1966, pp. 215-257.

(59) _____. The Formula Feed Industry, 1969, A Statistical Summary, SB-485, U.S. Dept. Agr., Econ. Res. Serv., May 1972.

(60) _____. Structure of the Feed Manufacturing Industry, 1975, A Statistical Summary, SB-596, U.S. Dept. Agr., Econ. Stat. Coop. Serv., 1978.

(61) University of Illinois. Alternatives for Grain Conditioning and Storage, Conference Proceedings, Urbana-Champaign, Jan. 18-19, 1978.

(62) Watson, Stanley A. "Industrial Utilization of Corn," Corn and Corn Improvement, G. F. Sprague, (Ed.) Agronomy 18, American Society of Agronomy, Madison, Wisc., 1977, pp. 721-763.

APPENDIX TABLES

Appendix table 1--Usual planting and harvesting dates, by State

State	Usual planting dates	Usual harvesting dates		
		Begin	Most active	End
Alabama	Mar. 20-June 5	Aug. 20	Sept. 15-Nov. 15	Dec. 5
Arizona	Apr. 15-June 1	Aug. 15	Oct. 1-Oct. 25	Nov. 10
Arkansas	Apr. 10-May 30	Sept. 10	Oct. 1-Nov. 10	Dec. 1
California	Apr. 15-July 1	Sept. 15	Oct. 1-Nov. 10	Nov. 30
Colorado	Apr. 25-June 1	Oct. 1	Oct. 10-Nov. 20	Dec. 1
Delaware	May 1-June 15	Sept. 5	Sept. 15-Oct. 20	Nov. 15
Florida	Mar. 1-Apr. 30	Aug. 15	Sept. 1-Sept. 30	Nov. 15
Georgia	Mar. 20-May 15	Sept. 1	Oct. 1-Nov. 1	Dec. 1
Idaho	May 1-May 25	Oct. 10	Oct. 25-Nov. 15	Dec. 10
Illinois	May 1-June 15	Oct. 1	Oct. 15-Nov. 15	Dec. 5
Indiana	May 1-June 10	Sept. 30	Oct. 10-Nov. 30	Dec. 10
Iowa	May 1-June 1	Oct. 5	Oct. 25-Nov. 25	Dec. 5
Kansas	Apr. 15-June 10	Sept. 15	Oct. 10-Nov. 15	Dec. 5
Kentucky	Apr. 20-June 15	Sept. 20	Oct. 5-Nov. 5	Nov. 25
Louisiana	Mar. 1-May 15	Aug. 1	Sept. 1-Oct. 1	Oct. 15
Maryland	May 1-June 15	Sept. 1	Sept. 15-Oct. 25	Nov. 20
Michigan	May 1-June 15	Oct. 1	Oct. 15-Nov. 15	Dec. 1
Minnesota	May 1-June 15	Oct. 5	Oct. 20-Nov. 15	Nov. 30
Mississippi	Apr. 1-May 31	Sept. 1	Oct. 15-Nov. 15	Dec. 10
Missouri	Apr. 20-June 1	Sept. 15	Oct. 10-Nov. 15	Dec. 20
Montana	May 10-June 10	Sept. 15	Sept. 20-Oct. 5	Oct. 15
Nebraska	Apr. 25-June 5	Sept. 25	Oct. 15-Nov. 10	Dec. 5
New Jersey	May 10-June 20	Oct. 5	Oct. 20-Nov. 10	Nov. 25
New Mexico	Apr. 15-June 8	Sept. 10	Oct. 10-Nov. 1	Dec. 1
New York	May 10-June 15	Oct. 10	Oct. 20-Nov. 15	Dec. 1
North Carolina	Apr. 1-June 10	Aug. 25	Oct. 1-Nov. 10	Jan. 1
North Dakota	May 15-June 20	Oct. 5	Oct. 10-Oct. 25	Nov. 5
Ohio	May 1-June 15	Sept. 25	Oct. 10-Nov. 5	Nov. 25
Oklahoma	Apr. 5-May 25	Sept. 1	Sept. 10-Oct. 15	Nov. 10
Oregon	May 5-June 10	Sept. 15	Sept. 25-Oct. 10	Oct. 20
Pennsylvania	May 1-June 20	Sept. 20	Oct. 1-Oct. 20	Nov. 10
South Carolina	Mar. 20-May 20	Sept. 1	Oct. 1-Nov. 10	Dec. 1
South Dakota	May 5-June 5	Oct. 1	Oct. 20-Nov. 5	Nov. 20
Tennessee	Apr. 15-June 15	Sept. 10	Oct. 15-Nov. 5	Dec. 5
Texas	Mar. 1-May 30	July 20	Sept. 25-Oct. 10	Nov. 1
Virginia	Apr. 15-June 25	Sept. 1	Oct. 1-Nov. 10	Dec. 1
Washington	May 1-June 5	Oct. 15	Oct. 25-Nov. 20	Dec. 15
West Virginia	May 1-June 5	Sept. 10	Sept. 15-Oct. 15	Nov. 1
Wisconsin	May 5-June 10	Oct. 10	Oct. 20-Nov. 10	Nov. 25
Wyoming	May 10-June 15	Oct. 15	Nov. 1-Nov. 15	Dec. 1

Source: Agricultural Handbook No. 283, Mar. 1972.

Appendix table 2--Onfarm storage capacity, by type of storage and State, Apr. 1, 1978

State	Type of storage			Total
	Shelled corn, other grains, oilseeds	Permanent ear-corn storage	Wet storage for high-moisture grain	
	Million bushels			
Alabama	27.8	16.9	4.3	49.0
Arizona	6.4	0	.4	6.8
Arkansas	50.1	.7	5.2	56.0
California	58.2	.3	7.5	66.0
Colorado	97.2	1.0	12.2	111.3
Delaware	3.6	1.5	.1	5.2
Florida	12.1	3.7	2.1	17.9
Georgia	87.7	11.7	5.6	105.0
Idaho	77.1	.5	4.0	81.6
Illinois	947.2	129.7	76.9	1,153.8
Indiana	430.0	52.1	24.5	506.6
Iowa	1,071.2	294.2	128.1	1,493.5
Kansas	336.5	3.8	25.3	365.6
Kentucky	89.3	39.3	10.0	138.6
Louisiana	39.9	1.4	3.9	45.2
Maine	2.2	0	1.4	3.6
Maryland	21.0	2.9	1.6	25.5
Massachusetts	9.7	.4	.1	10.2
Michigan	116.4	37.9	34.0	188.3
Minnesota	996.9	106.9	88.6	1,192.4
Mississippi	42.6	2.2	4.4	49.2
Missouri	309.1	19.9	17.4	346.4
Montana	278.8	.1	1.9	280.8
Nebraska	715.6	51.6	65.6	832.8
Nevada	3.0	0	0	0
New Jersey	8.1	1.9	1.1	11.1
Ner Mexico	9.1	0	.9	10.0
New York	37.6	9.6	14.5	61.7
North Carolina	100.9	17.0	8.1	126.0
North Dakota	681.4	1.2	8.7	691.3
Ohio	225.3	51.3	15.1	291.7
Oklahoma	76.7	.7	5.3	82.7
Oregon	33.5	.2	2.0	35.7
Pennsylvania	62.5	53.5	19.1	135.1
Rhode Island	.5	0	0	.5

Continued--

Appendix table 2--Onfarm storage capacity, by type of storage and State, Apr. 1, 1978--Continued

State	Type of storage			Total
	Shelled corn, other grains, oilseeds	Permanent ear-corn storage	Wet storage for high-moisture grain	
	Million bushels			
South Carolina	31.5	5.8	2.3	39.6
South Dakota	394.4	27.1	21.1	442.6
Tennessee	43.2	17.3	5.3	65.8
Texas	241.9	6.0	17.6	265.5
Utah	15.2	0	1.6	16.8
Virginia	37.6	8.0	5.7	51.3
Washington	59.7	.1	2.0	61.8
West Virginia	4.8	3.5	.4	8.7
Wisconsin	220.0	99.4	74.0	393.4
Wyoming	19.5	.1	.9	20.5
United States	8,133.4	1,082.5	731.0	9,946.9

Source: (47).

Appendix table 3--Whole grain weights, measures, and conversion factors1/

Grain	Weight per bushel	Per metric ton	Per quintal
	Pounds	Bushels	
Barley	48	45.9296	4.59
Buckwheat	48	45.9296	4.59
Corn:			
Shelled	56	39.6383	3.96
Ear husked	70	31.4946	3.15
Flaxseed	56	39.6383	3.96
Oats:			
Light	32	68.8945	6.89
Heavy	38	58.0164	5.80
Rice, rough	45	48.9916	4.90
Rye	56	39.6383	3.96
Grain sorghum	56	39.6383	3.96
Soybeans	60	36.7437	3.67
Wheat	60	36.7437	3.67

1/ Miscellaneous factors:

Rice: 1 cwt of rough rice = 2.2 bushels
1 barrel of rough rice = 162 pounds or 3.6 bushels
Sorghum grain: 1 cwt of sorghum grain = 1.78 bushels
Soybeans: 1 cwt of soybeans = 1.67 bushels

1 metric ton = 22.046 hundredweight
1 metric ton = 2,204.623 pounds
1 short ton or ton = 2,000 pounds
1 long ton = 2,240 pounds
1 quintal = 220.46 pounds
10 quintals = 1 metric ton
1 hectare = 2.471 acres

Source: (13, p. 31).

☆U.S. GOVERNMENT PRINTING OFFICE: 1982-360-932:ERS-1032